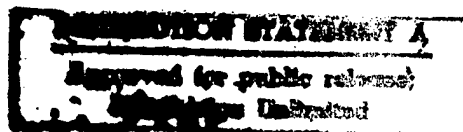


USSR REPORT  
ENGINEERING AND EQUIPMENT

14 November 1984

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UDC:539.4:629.7.02

ITERATIVE METHOD OF CALCULATING STRENGTH OF AIRFRAME MEMBERS USING FINITE ELEMENT METHOD

Kazan IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: AVIATIONNAYA TEKHNIKA  
in Russian No 4, Oct-Dec 83 (manuscript received 26 Apr 82) pp 9-14

BASTRAKOV, S. M., DENISOV, Yu. A., and POPOV, Yu. G.

[Abstract] Problems of deriving the exact solution of systems of linear equations more rapidly for analyzing structures stated nonlinearly are examined, along with aspects of developing the iterative method further. The iterative strength analysis method is extended from the shift method (beam scheme) to the method of forces. Reducing the problem of analyzing airframe members under conditions of physical nonlinearity to matrix manipulation by augmentation during each iteration speeds up the calculation by a factor of 6-9 over solutions using other manipulation methods in all stages. References 6 Russian.  
[214-6900]

UDC:629.735.33.027.2(088.8)

DETERMINATION OF PARAMETERS OF CUPPED AIRCRAFT LANDING SKI

Kazan IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: AVIATIONNAYA TEKHNIKA  
in Russian No 4, Oct-Dec 83 (manuscript received 3 Mar 81) pp 105-108

CHURUSOV, A. K.

[Abstract] The parameters of cup-shaped circular aircraft landing skis are analyzed. It is found that circular skis provide an effective means for improving aircraft ground mobility. Figures 4, references 2 Russian.  
[214-6900]

ANALYTICAL CONSTRUCTION OF FLIGHT VEHICLE SURFACES

Kazan IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: AVIATIONNAYA TEKHNIKA  
in Russian No 4, Oct-Dec 83 (manuscript received 2 Mar 82) pp 100-102

SNIGIREV, V. F.

[Abstract] A functional is examined that simplifies the selection of the combined approximating functions on the interpolation node grid to account for arbitrary arrangement of the interpolation nodes. An example is presented to investigate the convergence of a numerical solution of the problem of determining the surface (spline) parameter  $m(x,y)$ . Figures 2, references 5 Russian.

[214-6900]

UDC 621.039.8.002:621.039.554

DEPENDENCE OF  $^{233}\text{U}$  PRODUCTION FROM  $^{232}\text{Th}$  ON NEUTRON SPECTRUM

Moscow ATOMNAYA ENERGIYA in Russian Vol 56, No 5, May 84  
(manuscript received 3 Oct 83) pp 320-322

GERASIMOV, A. S., KISELEV, G. V. and RUDIK, A. P.

[Abstract] The process of  $^{233}\text{U}$  production from  $^{232}\text{Th}$  through  $^{233}\text{Pa}$  is analyzed for the purpose of determining how the  $^{233}\text{U}$  concentration and the number of absorbed neutrons depend on the burnup of  $^{232}\text{Th}$  as well as on the neutron flux density and the neutron energy spectrum. Calculations take into account the thermal cross sections for absorption and the resonance absorption integrals, including fission and radiative capture. While resonance absorption in  $^{232}\text{Th}$  is inhibited under real conditions, its integral was evaluated assuming an infinite dilution and calculations then made for three intermediate values of this integral. Calculations were made for two levels of neutron flux density ( $5 \cdot 10^{13}$  and  $1 \cdot 10^{14} \text{ cm}^{-2}\text{s}^{-1}$ ) with the effective rigidity of the neutron spectrum 0, 0.2, or 0.4 at each flux density level, these values corresponding the thermal neutrons. With  $x_1(t)$ ,  $x_2(t)$ ,  $x_3(t)$  denoting respectively the concentrations of  $^{232}\text{Th}$ ,  $^{233}\text{Pa}$ ,  $^{233}\text{U}$  as functions of time, equations were solved for  $x_2(t) + x_3(t)$  representing the amount of reprocessed  $^{233}\text{U}$ ,  $[x_1(0) - x_1(t)]/[x_2(t) + x_3(t)]$  representing the consumption of  $^{233}\text{Th}$  nuclei per nucleus of  $^{233}\text{Pa} + ^{233}\text{U}$  mixture, and  $x_2/(x_2 + x_3)$  as a function of  $x_2 + x_3$  representing the  $^{233}\text{Pa}$  content. Also calculated were the consumption of neutrons  $R$  and the energy released by fission of  $^{233}\text{U}$  in one ton of  $^{233}\text{Th}$ , both as functions of  $x_2 + x_3$ . The results reveal physical characteristics of the  $^{232}\text{Th} \rightarrow ^{233}\text{U}$  process as functions of the neutron flux density and the neutron energy spectrum, data useful for reactor design. They also indicate that a non-trivial solution of the economic optimization problem may be obtained by lowering the  $^{233}\text{Th}$  consumption and increasing the neutron consumption with increasing rigidity of the neutron spectrum. Figures 6, references 7: 6 Russian, 1 Western.  
[234A-2415]

## CRYOGENIC LOOP FOR GAMMA-RADIATION SOURCES

Moscow ATOMNAYA ENERGIYA in Russian Vol 56, No 5, May 84  
(manuscript received 21 Sep 83) p 319

BUZUKASHVILI, I. I. and KARUMIDZE, G. S.

[Abstract] A cryogenic loop for gamma-radiation sources operating at 80 K in the indium-gallium system of the IRT-2M research reactor has been developed at the Institute of Physics, GSSR Academy of Sciences. Its distinctive feature is the use of chemically pure argon rather than spectroscopically pure nitrogen to avoid buildup of hazardous azides, and cooling of the argon with only commercially pure nitrogen outside the radiation field. The loop consists of a vertical channel containing argon and a rod with the radiation source at the lower tip, passing through a liquid-nitrogen bath in a container, both surrounded by a vacuum jacket and the rod extending beyond the channel through a gland seal at the upper end. After the channel has been evacuated to a residual pressure of 1.3 Pa, liquid nitrogen is pumped from a tank to the container until a pressure of 0.2 MPa (85 K boiling point) has been reached in the latter. Then argon from a gas tank is admitted into the channel above the liquid-nitrogen container for subsequent cooling, condensation, and downward flow as liquid without freezing. While cooling the radiation source at the bottom, the argon evaporates and then flows upward as gas, past the liquid-nitrogen bath which recondenses it. The equipment includes four valves, a manometer and a vacuum gauge. This cryogenic loop can maintain 50 W radiation sources or simulator specimens at temperatures within the 85-100 K range. Radioactive argon produced by the  $^{40}\text{Ar}(n,\gamma)^{41}\text{Ar}$  reaction must be removed for radiation safety. The authors thank V. A. Chernomordin, N. N. Datunayshvili and R. B. Lyudvigov for assistance in testing the loop. Figure 1, references 5: 3 Russian, 2 Western.  
[234A-2415]

UDC 621.039.516.22

ACCOUNTING FOR DECAY OF  $^{238}\text{Pu}$  IN DETERMINATION OF ISOTOPE CONTENT OF URANIUM FUEL IN HYBRID REACTOR

Moscow ATOMNAYA ENERGIYA in Russian Vol 56, No 5, May 84  
(manuscript received 18 Aug 83) pp 315-316

MARIN, S. V. and SHATOLOV, G. Ye.

[Abstract] The isotope content of uranium in the blanket of a fusion-fission reactor with a high energy neutron field is evaluated, specifically the dependence of  $^{232}\text{U}$ ,  $^{234}\text{U}$  and  $^{235}\text{U}$  content in depleted uranium fuel on the natural radioactive decay of  $^{238}\text{Pu}$  and  $^{235}\text{Np}$ . Taken into consideration are closed nuclear transformation chains that produce  $^{234}\text{U}$  and  $^{235}\text{U}$  makeup,



noticeable especially at low  $^{235}\text{U}$  levels, while also possibly raising the  $^{232}\text{U}$  content, which is undesirable from the standpoint of radiation safety. Calculations have been made for a tokamak reactor as model, the problem being reduced to a system of ordinary differential equations according to the BURNFL program. This system was solved analytically rather than by numerical integration to reveal the combination of governing functions and any small effects that would otherwise remain masked. Final evaluation on a BESM-6 high-speed computer with double-precision arithmetic has yielded the kinetics of isotope content in the blanket space near the first wall under a neutron load increasing from 1 to 50 MW/m<sup>2</sup> during irradiation, such an increase being equivalent to a corresponding compression of the real time scale, with an exponential factor smoothing the oscillatory part of the solution. The results indicate that the  $^{234}\text{Pu}$  content in depleted fuel in such a reactor does not exceed the  $^{234}\text{Pu}$  content in natural uranium, but it contributes to a higher  $^{232}\text{U}$  content by approximately  $2.10^{-6}$  kg/t, while  $^{234}\text{U}$  in the original fuel contributes approximately  $35.10^{-6}$  kg  $^{232}\text{U}$ /t. Figures 3, references 5: 4 Russian, 1 Western.  
[234A-2415]

UDC 621.039.516.22

# ISOTOPE CONTENT OF FUEL IN BLANKET OF HYBRID REACTOR WITH THORIUM CYCLE

Moscow ATOMNAYA ENERGIYA in Russian Vol 56, No 5, May 84  
(manuscript received 18 Sep 83) pp 289-291

MARIN, S. V. and SHATALOV, G. Ye.

[Abstract] The performance of hybrid reactors as sources of power and as re-processors of secondary nuclear fuel depends largely on the isotope content of the original charge and the change in isotope content under prolonged irradiation. This aspect of operation is analyzed here for a fusion-fission reactor with a thorium fuel chain and high probability of (n,2n) or (n,3n) reactions in a reactor blanket with a high-energy neutron field and spectrum. The reactions  $^{232}\text{Th}(n,2n)^{231}\text{Th} \rightarrow \dots \rightarrow ^{232}\text{U} - \dots, ^{232}\text{Th}(n,\gamma)^{233}\text{Th} \rightarrow ^{233}\text{Pa} \rightarrow \dots, ^{233}\text{U}(n,2n)^{232}\text{U} \rightarrow \dots, ^{230}\text{Th}(n,\gamma)^{231}\text{Th} - \dots \rightarrow ^{232}\text{U} \rightarrow \dots, ^{230}\text{Th}(n,3n)^{228}\text{Th} \rightarrow \dots, ^{230}\text{Th}(n,2n)^{229}\text{Th}(n,2n)^{228}\text{Th} - \dots$  have been evaluated according to the BURNFL program. Data obtained as a result include the mean concentrations of Th, Pa, U isotopes in the fuel and of U isotopes in reprocessed uranium after 200-1000 days of irradiation, as well as maximum, average, and minimum amounts of  $^{232}\text{U}$  in uranium in such a hybrid reactor (for comparison, also in a liquid-metal fast breeder reactor). The data indicate approximately 92%  $^{233}\text{U}$  and 7%  $^{232}\text{U}$  in depleted fuel in the blanket of the given hybrid reactor. Figures 2, tables 3, references 6: 4 Russian, 2 Western.  
[234A-2415]

## WITHDRAWAL OF SUPPLEMENTARY ABSORBERS FROM CORE OF RBMK-1000 MW WATER-GRAPHITE CHANNEL REACTOR

Moscow ATOMNAYA ENERGIYA in Russian Vol 56, No 5, May 84  
(manuscript received 10 Aug 83) pp 230-231

ISAYEV, N. V., DRUZHININ, V. Ye. and SHMONIN, Yu. V.

[Abstract] The strategy of channel recharging in the RBMK-1000 MK water-graphite channel reactor of the Kursk AES, whose core contains 234 supplementary absorbers and 44 spare channels with water columns, involves optimal periodic withdrawal of the supplementary absorbers during a transient period (7-8 years) without violation of symmetry so as to ensure optimum technical and economic indicators of steady-state operation. Absorbers are ready for withdrawal within 670-700 effective operating days. The strategy of channel recharging according to the OPERA optimization program is based on a full-scale, two-group diffusion model that covers partial and continuous recharges. This strategy includes control of the energy release distribution through regulation of the immersion depth of control rods. It also includes the OPTIMA program of equalizing the energy release distribution, appropriately modified (the original OPTIMA program being devised for equalization through overcompensation of the reactivity). In the OPERA program, constraints are stipulated not only on the immersion depth of control rods but also on the maximum channel power, the maximum radial and altitudinal nonuniformity, the maximum regulation error, the minimum available power margin and the minimum available reactivity margin. Essential results of calculations according to this program agree within 1% with those based on the REF program of transient analysis assuming a homogenized reactor core. Subcriticality and protection level are usually checked according to the SAFETY program, which requires 25-30 min machine time on a YeS 1052 computer. Since the OPTIMA program requires only 4-7 min machine time, the most reactive state can be established according to the fast SOS program for subsequent execution of the OPERA/OPTIMA. The characteristics of processes attending withdrawal of absorbers have been thus calculated and on this basis the most expedient mode and sequence of withdrawal are recommended. References 4 Russian.  
[234A-2415]

UDC 621.039.586

FAILURE WITH BREAK IN MAIN CIRCULATION PIPE IN VVER-1000 MW WATER-MODERATED  
WATER-COOLED POWER REACTOR

Moscow ATOMNAYA ENERGIYA in Russian Vol 56, No 4, Apr 84  
(manuscript received 14 Jun 83) pp 232-234

BOYADZHIYEV, A. I. and STEFONOVA, S. Y., Bulgarian Academy of Sciences, Sofia

[Abstract] Loss-of-coolant modes of failure in a water-moderated, water-cooled power reactor or a pressurized-water reactor have been analyzed theoretically, including heavy transient mechanical loads of millisecond duration on reactor auxiliaries and heavy transient thermal loads of seconds duration on fuel elements. Calculations were made specifically for a break in the 850 mm main circulation pipe in a 1000 MW water-moderated, water-cooled power reactor, according to the algorithm of the RELAP4/MOD6 program. In this program the primary loop is subdivided into 35 control segments with 45 interconnections, their geometrical and thermohydraulic characteristics most closely approaching the real ones. The loop is replaced by two equivalent loops: a faulty one and a tripartite intact one consisting of the reactor core, one undeformed fuel element, and a stack of four energy-release zones along the reactor height with an average linear power density of 170 W/cm. Boundary conditions are stipulated at the pipe break and at the steam generator on the side of the secondary loop. Initial conditions are stipulated regarding the change in energy release intensity and the cut-in of pumped-storage tanks and pumps upon loss of pressure. The results indicate a 25 s period of coolant discharge between rupture of pipe and restoration of pressure: fluctuation of coolant flow rate through the reactor core for 5 s, excessive backpressure for 5-15 s, nearly complete loss of coolant after 15-20 s, and fuel-cladding temperature equalization with stabilization of the heat transfer coefficient at 100 W/(m<sup>2</sup>·K) at the end of that period. Accordingly, neither the melting point of the fuel (~3000 K) nor the plastic yield point of zirconium cladding (~1000 K) is reached. Figures 3, references 12: 1 Russian, 3 Czech, 8 Western. [234-2415]

UDC 621.039.6:537.531.9

HEATING OF FOCUSING OPTICS IN LASER FUSION REACTORS BY X-RADIATION  
FROM TARGETS

Moscow ATOMNAYA ENERGIYA in Russian Vol 56, No 4, Apr 84  
(manuscript received 21 Feb 83) pp 225-226

BELOUSOV, N. I., GRISHUNIN, P. A., SUBBOTIN, VI. I. and KHARITONOV, V. V.

[Abstract] Focusing lenses and mirrors in a laser fusion reactor may absorb much more x-radiation emitted by the target than laser radiation, the dominant mechanism being the photoelectric effect on atomic electrons. The process

is analyzed here, assuming exponential depthwise attenuation of the photon flux. The temperature rise at the surface of a metal mirror or transparent lens caused by an x-radiation pulse is calculated as an integral with respect to energy, the expression including physical and thermophysical properties of the optics material as well as the ratio of thermal diffusion distance to photon flight distance. This relation indicates how the temperature rise can be held below the melting point, namely the maximum permissible energy density of an absorbable x-radiation pulse. The minimum permissible focal length is then determined as a function of the parameters of the fusion target, the physical properties of the focusing optics, and the spectrum of the x-radiation. Figure 1, references 7: 2 Russian, 5 Western. [234-2415]

UDC 539.12.08.126.5

#### MEASUREMENT OF FUEL BURNUP IN NUCLEAR REACTOR ON BASIS OF NEUTRINO EMISSION

Moscow ATOMNAYA ENERGIYA in Russian Vol 56, No 4, Apr 84  
(manuscript received 17 Nov 83) pp 214-218

KOROVKIN, V. A., KODANEV, S. A., YARICHIN, A. D., BOROVY, A. A.,  
KOPEYKIN, V. I., MIKAELIAN, L. A. and SIDORENKO, V. D.

[Abstract] As one promising practical use of the neutrino, a method of measuring the fuel burnup in a nuclear reactor has been developed that utilizes neutrino emission in accordance with the reaction  $\bar{\nu}_e + p \rightarrow n + e^+$  of neutrino and hydrogen. The basis of such a measurement is the relation between the number of neutrino detector readings and the number of fissions in the reactor, which takes into account the kinetics and the cross sections as well as spectra of the particles participating in the process. The method is refined on the basis of error analysis giving a correction factor that accounts for the variable contribution of beta-electrons and various actinides to the process. The method was tested against a scintillation spectrometer in a VVER-440 water-moderated, water-cooled 440 MW power reactor. The authors thank M. A. Markov for interest and stimulation, V. A. Legasov for assistance and direction, A. G. Zelenkov for discussions, and colleagues at physical and thermophysical laboratory for discussions and participation in measurements. Figures 5, table 1, references 16: 13 Russian, 3 Western. [234:2415]

## PASSIVE STABILIZATION OF VERTICAL INSTABILITY IN TOKAMAK REACTOR

Moscow ATOMNAYA ENERGIYA in Russian Vol 56, No 4, Apr 84  
(manuscript received 17 Oct 83) pp 210-212

BESPOLUDENNOV, S. G., GALKIN, S. A., DEGTYAREV, L. M. and PISTUNOVICH, V. I.

[Abstract] Stabilization of fast vertical instability in a tokamak reactor is considered, such an instability of the plasma column occurring in the absence of active stabilizer operating through feedback. A sheath of conducting material or an array of conducting loops have been proposed for this purpose. Passive stabilization on the other hand must not attenuate the neutron flux from plasma to blanket and therefore the blanket itself could serve this purpose. Here the instability problem and its solution are analyzed in the approximation of rigid displacement of the plasma column. The corresponding field equations and equation of motion are formulated in a toroidal system of coordinates, taking into account the symmetry with respect to the angular coordinate. A numerical solution has yielded the coordinates of equilibrium loops and the currents they carry. The results indicate that the first wall and the blanket with an effective electrical conductivity of 10-20 kS provide sufficient stabilization so as not to require additional passive feedback, while aluminum loops provide active feedback with an adequate response speed of 15-30 ms. Figures 2, table 1. [234-2415]

## DISCHARGE OF WET STEAM FOLLOWING BREAK IN COOLANT CIRCULATION LOOP IN NUCLEAR REACTIONS

Moscow ATOMNAYA ENERGIYA in Russian Vol 56, No 4, Apr 84  
(manuscript received 25 Aug 83) pp 202-205

MIRONOV, Yu. V. and FOMICHEVA, T. I.

[Abstract] A procedure is developed for analyzing, from the safety standpoint, the discharge of wet steam following a hypothetical break in the coolant circulation loop in a water-graphite channel reactor. Calculations are based on the fundamental equations of a one-dimensional model of two-phase flow, taking into account the pressure dependence of thermophysical properties and consequently nonuniform longitudinal profiles of the latter. Thermodynamic stability is assumed, considering that metastability and large temperature drops below the boiling point of water occur only within a very narrow range of operating conditions. The algorithm of the solution has been programmed in ALGOL for a BESM-6 high-speed computer. This program KRITIKA-3 is applicable to an arbitrary number of circulation loop segments of various

cross sections, uniform and variable ones, separated by conventional high-drag transitions. The program yields the critical channel section. Input data include pressure and heat content at the channel inlet, thermodynamic properties taken from tables, and a constraint on the outlet pressure that it does not at any point drop below the ambient pressure. A special version of the program covers failure of pipes carrying superheated steam, with internal pressure jumps, and with sudden channel expansions. Figures 2, references 9: 5 Russian, 4 Western.  
[234-2415]

UDC 669.14.8

#### USE OF OKh1MF STEEL IN NUCLEAR POWER ENGINEERING

Moscow ATOMNAYA ENERGIYA in Russian Vol 56, No 4, Apr 84  
(manuscript received 1 Aug 83) pp 199-202

MEDNIKOV, A. K., KRUTIKOV, P. G., SEDOV, V. M., BORISOV, V. P.,  
LOSHKOVA, L. I. and SLOBIN, A. S.

[Abstract] The main deficiencies of austenitic chromium-nickel steels now widely used in nuclear power plants are proneness to strain hardening in service and to corrosion cracking in the presence of  $\text{Cl}^-$  ions, low yield strength and low fatigue strength, low thermal conductivity and high linear expansivity, and formation of cobalt radionuclides upon activation of the corrosion products. Since these deficiencies are attributable to the presence of nickel in these steels, a nickel-free chromium steel OKh1MF has been developed at the Central Scientific Research Institute of Machine Manufacturing Technology for separators of steam superheaters, water-graphite channel reactors, and heat exchanger grids in atomic electric power plants and atomic heating plants. This martensitic-ferritic steel retains all the excellent qualities of stainless steels, with better mechanical characteristics over a wide temperature range, with proneness to cold hardening, and not requiring heat treatment of bends. Ingots and forgings as well as hot-rolled and cold-rolled plates and tubing of this steel have been tested in the laboratory for mechanical properties at temperatures from 20 to 500°C for anodic polarization in inorganic acids (1 N HCl, 1 N  $\text{HNO}_3$ , 1 N  $\text{H}_2\text{SO}_4$ ) at room temperature and after subsequent soaking in distilled water at room temperature for up to 500 h, for corrosion rate in borated water (10 g/kg  $\text{H}_3\text{BO}_3$  + 0.02 g/kg KOH, pH = 8.25) and in water bidistillate (1 mg/kg  $\text{O}_2$ ) at 350°C, and in 0.01-1.0 N solutions of acids ( $\text{HNO}_3$ , HCl,  $\text{H}_2\text{SO}_4$ ,  $\text{H}_2\text{C}_2\text{O}_4$ ) at room temperature. Products of this steel have been tested for corrosion resistance in a special holding tank at the Leningrad AES, as delivered, after mechanical finish treatment, in contact with OKh18N10T steel with welds made by automatic and manual argon-arc welding, with the specimens in either vertical or horizontal position. The results indicate high overall corrosion resistance, especially resistance to pitting,  $\text{H}_2\text{SO}_4$  and HCl solutions being most aggressive toward this steel. The corrosion rate of

manually arc-welded seams is much higher than that of automatically arc-welded ones. Heat exchanger tube bundles of this steel were examined after 5000 h of industrial testing. V. A. Shishkunov and A. A. Afanas'yev performed the analyses after industrial testing of heat exchanger tube bundles. Figures 2, tables 5, references 7 Russian.  
[234-2415]

UDC 621.039.542

PHYSICAL AND CHEMICAL INTERACTION OF OXIDE FUEL AND FUEL ELEMENT CLADDING  
IN FAST REACTOR

Moscow ATOMNAYA ENERGIYA in Russian Vol 56, No 4, Apr 84  
(manuscript received 4 Jul 83) pp 195-199

TSYKANOV, V. A., DAVYDOV, Ye. F., KLOCHKOV, Ye. N., SHAMARDIN, V. K.,  
GOLOVANOV, V. N. and KRYUKOV, F. N.

[Abstract] A study was made of physical and chemical interaction of pelletized oxide fuel (U,Pu)O<sub>2</sub> containing fission products and the steel cladding (austenitized OKh16N15M3B) of fuel elements in a BOR-60 bare fast reactor. Polished specimens of fuel and cladding had been cut from segments corresponding to various interaction zones. Fuel elements with maximum linear power density of 53 kW/m and up to 14% burnup of heavy elements had been selected, the temperature of the cladding allowed to vary from 770 to 960 K. Microstructural examination was done under an MIM-14 optical microscope and the distribution of chemical elements was determined by an MAR-2 x-ray microanalyzer. The results reveal four modes of corrosion: general corrosion associated with the presence of cesium, the corrosion product containing iodine also in the thermodynamically stable CsI compound; intercrystalline corrosion in the presence of cesium, intercrystalline corrosion in the presence of iodine, and mixed corrosion in the presence of tellurium. Chemical elements in the corrosion products are distributed uniformly up to 850 K and segregate (Cr-Cs, Cr-Fe, CsI, Fe, Ni) at higher temperatures. The depth of corrosion increases with higher temperature and with increased depletion of heavy elements, mixed corrosion occurring after irradiation of fuel elements to a high burnup above 8%. Under special conditions, Cs<sub>x</sub>CrO<sub>4</sub> (x = 2-5) compounds form on the inner surface and M<sub>23</sub>C<sub>6</sub> carbides form in the bulk of the steel cladding. Tellurium vapor migrating to the periphery of the fuel element core forms compounds, either Cs<sub>2</sub>Te or UOTe. Figures 5, tables 1, references 10: 5 Russian, 5 Western.  
[234-2415]

NON-NUCLEAR ENERGY

UDC 621.472:662.987

ANALYSIS OF EFFICIENCY OF TWO-LOOP SOLAR HOT WATER SYSTEM WITH REFLUX HEAT EXCHANGER

Tashkent GELIOTEKHNICA in Russian No 1, Jan 84 (manuscript received 25 Jun 82) pp 40-44

RABINOVICH, M. D., Kiev Regional Scientific Research and Planning Institute for the Standard and Experimental Design of Residential and Public Buildings

[Abstract] An engineering method for designing dual-loop solar water heating systems employing reflux heat exchangers is developed and analyzed theoretically. Equations are derived for the heat transfer in the solar collector and heat exchanger and for calculating heat efficiency. An expression is derived for finding the efficiency of the solar heating system as the product of so-called dimensionless quantities that characterize the efficiency of individual thermal processes in the system. System efficiency is calculated as a function of the NTU. Figures 2, references 3: 1 Russian, 2 Western. [218-6900]

UDC 621.472

PROSPECTS FOR USE OF CHEMICALLY REACTING WORKING FLUIDS IN HELIONICS

Tashkent GELIOTEKHNICA in Russian No 2, Feb 84 (manuscript received 12 Jan 83) pp 8-12

UMAROV, G. Ya., NESTERENKO, V. B., SPIVAK, S. I., BUBNOV, V. P. and UMAROV, A. G., Physical-Technical Institute imeni S. V. Starodubtsev, Uzbek SSR Academy of Sciences, Institute of Nuclear Electronics, Belorussian SSR Academy of Sciences

[Abstract] The gas and gas-liquid cycles accomplished with  $N_2O_4$  as the working fluid are examined in detail. The advantages of these cycles over gas-turbine cycles employing inert gases and steam-turbine cycles on which existing and planned solar and solar-fuel power plants are based are analyzed.



The use of dissociating gases in modular and power-type solar and solar-fuel power plants makes it possible to increase the efficiency and to reduce the cost of the electricity produced. Figures 4, references 20: 15 Russian, 5 Western.  
[232-6900]

UDC 662.997:662.93

#### ABSORPTION HEAT TRANSFORMERS IN SOLAR HEATING AND COOLING SYSTEMS

Tashkent GELIOTEKHNICA in Russian No 1, Jan 84 (manuscript received 28 Jun 82) pp 29-35

GROSMAN, E. R., SHAVRIN, V. S., TOLSTYKH, I. P. and SVERDLOVA, O. A.,  
Institute of Technical Thermal Physics, Ukrainian SSR Academy of Sciences

[Abstract] The energy efficiency of compression and absorption machinery is analyzed and compared. It is found that the technical and economic indicators of the compared cooling systems are approximately the same if the specific reduced cost per kilowatt hour of electricity is six times greater than that for producing one kilowatt hour of thermal energy. If this ratio is higher, solar systems employing absorption units will be more economical. The design of a solar-based heat pump heating system is described and analyzed. Figures 3, references 5: 3 Russian, 2 Western.  
[218-6900]

UDC 62-52:552.58:668.991

#### ENERGY OPTIMALITY CRITERION FOR AUTOMATIC FLAT HELIOSTAT CONTROL SYSTEM

Tashkent GELIOTEKHNICA in Russian No 1, Jan 84 (manuscript received 9 Jun 82) pp 27-28

DUBILOVICH, V. M. and KOSTYUKOVSKIY, A. G., Belorussian Branch, State Scientific Research Higher Engineering Institute imeni G. M. Krzhizhanovskiy

[Abstract] Stabilization accuracy requirements are examined from the viewpoint of solar energy lost at the collector. Losses associated with selective absorption and scattering of light energy in the surrounding medium are disregarded. The Feldbaum criterion turns out to be the system optimality criterion; the time constant of the optimality criterion depends on the values of the indicators characterizing the heliostat drive, the heliostat as a whole, as well as its position relative to the collector, and the collector itself. Figure 1, references 4 Russian.  
[218-6900]

UDC 621.315.592

CHARACTERISTICS OF CURRENT TRANSMISSION IN POLYCRYSTALLINE FILMS WITH INTER-CRYSTAL BARRIERS

Tashkent GELIOTEKHNIKA in Russian No 1, Jan 84 (manuscript received 12 Jan 83) pp 3-6

ATAKULOV, Sh. B., RASULOV, R. Ya. and SHAMSIDDINOV, A. N., Fergana State Pedagogic Institute imeni Ulugbek, Uzbek SSR Ministry of Education

[Abstract] The characteristics of current transmission in a polycrystalline film with intercrystal barriers due to the trapping of charge carriers on surface states at the crystallite boundary are studied. Electrical conductance is calculated by finding the potential barriers at the points of contact between two and four crystallites. The depletion region near the point of contact of four crystallites is analyzed on the basis of the geometry of the problem. The height of barriers in the two- and four-crystallite regions is determined. The conditions under which "cutoff" occurs in the four-crystallite region are analyzed. Figures 3, references 5 Russian. [218-6900]

UDC 662.997:621.187.142.001.5

RESULTS OF COMPARATIVE TESTS OF SOME DIFFERENT VERSIONS OF SOLAR WATER DISTILLATION INSTALLATIONS

Tashkent GELIOTEKHNIKA in Russian No 2, Feb 84 (manuscript received 5 Apr 82) pp 61-63

KAKHAROV, S., ACHILOV, B. M., ZHARAYEV, T. D. and SATTIKULOV, J., Bukhara State Pedagogical Institute imeni S. Ordzhonikidze, Uzbek Ministry of Education

[Abstract] The application of two versions of novel solar stills with separate chambers is described. Comparative mean daily test data are presented for versions employing a glass-film coating and employing two layers of glass. It is found that when two layers of glass are used the output of the device can be increased, providing 1500-1600 liters of distillate annually per square meter of physical area, which is 1.5 times the output of the single-glass version. Figures 2, references 3 Russian. [[232-6900]

UDC 662.997:621.472

INVESTIGATION OF CHARACTERISTICS OF SOLAR INSTALLATIONS UNDER CONDITIONS  
IN KABUL

Tashkent GELIOTEKHNICA in Russian No 2, Feb 84 (manuscript received  
15 Aug 83) pp 52-54

SADYKOV, B. S., BARAMIDZE, S. S. and DZHAMDAR, M., Kabul Polytechnical  
Institute, Central Design Institute

[Abstract] The results of tests performed on a "hot box" installation in  
Kabul are presented. The specifications of the collector, which employs  
water as the heat medium, are presented. The mean daily solar radiation  
on a horizontal surface in Kabul is tabulated by months of the year. Plans  
are discussed for a solar-heated pool employing an asphalt heat reservoir.  
Figures 2, references 2 Russian.  
[232-6900]

UDC 662.997:662.93

THERMAL ANALYSIS OF HELIOTHERMOSTAT WITH CONVECTOR DESIGNED AS HEAT TUBE

Tashkent GELIOTEKHNICA in Russian No 2, Feb 84 (manuscript received  
12 Feb 82) pp 48-52

RZAYEV, P. F., VELIYEVA, B. A. and MAMEDOVA, A. N., Radiation Physics Section,  
Institute of Physics, Azerbaijan SSR Academy of Sciences

[Abstract] A device based on the principle of reversible endothermic pro-  
cesses is proposed that enables thermostatic control of solar-aided vessels.  
The device consists of a "hot box" and a thermostat connected together by  
a heat tube. The solar energy concentrated by the hot box heats a medium  
(water) in the branching boiling zone of the heat tube to the boiling point.  
The vapor that forms passes through the adiabatic zone and condenses in  
the condensation zone, releasing the heat obtained in the hot box. When  
the solar radiation ceases, i.e., at night, the device continues to operate  
by using heat stored by means of liquid paraffin. Optimum parameters of  
the device are computed. References 5 Russian.  
[232-6900]

SOME FEATURES OF OPERATION AND ANALYSIS OF SOLAR STILLS

Tashkent GELIOTEKHNIKA in Russian No 2, Feb 84 (manuscript received 16 Apr 82) pp 44-48

NOVIKOVA, V. I., Institute of Heat- and Mass Exchange imeni A. V. Lykov, Belorussian SSR Academy of Sciences

[Abstract] Criterial relationships are derived for describing the transfer processes occurring in a solar still. Full-scale experiments are conducted on models of flat-plate solar stills in which it is established that when the evaporation condensation surfaces are separated by 10 mm most of the vapor is transferred by diffusion, with less than 10% being transferred by convection. As the distance between the surfaces increases, the role of the diffusion flux becomes smaller and convective mass transfer increases, but so do the heat losses caused by convective heat exchange. It is concluded that the output of solar stills can be improved only by recuperating heat and minimizing heat losses that cannot be recuperated. Figure 1, references 18: 14 Russian, 4 Western. [232-6900]

AIR CONDITIONING BY SOLAR EVAPORATIVE COOLING AND STORAGE OF COLD

Tashkent GELIOTEKHNIKA in Russian No 2, Feb 84 (manuscript received 4 Feb 83) pp 41-44

KLYSHCHAYEVA, O., Solntse Scientific Production Association, Ashkhabad

[Abstract] A simple method for storing cold is proposed to even up the daily cooling load in buildings in hot climates. In the proposed method, the solution circulating in the system is diluted when there is little or no solar radiation. The method can be used in solar absorption cooling plants employing a convective cooling system, in which solar and evaporative cooling are combined, to extend the operation of the plant beyond the hours when solar radiation is present; when solar and evaporative cooling are combined, the proposed system levels out the daily cooling load. Figure 1, references 8 Russian. [232-6900]

## SES-5 TEST GROUND: DIAGNOSIS OF ACCURACY OF HELIOSTAT MIRROR SURFACE

Tashkent GELIOTEKHNIKA in Russian No 2, Feb 84 (manuscript received 31 Aug 83) pp 35-37

TEPLYAKOV, D. I. and APARISI, R. R., State Scientific Research Power Engineering Institute imeni G. N. Krzhizhnovskiy

[Abstract] A quick method is proposed for estimating the effective accuracy of a heliostat mirror surface. Experiments using the stationary heliostat method at the SES-4 test ground took 10-13 minutes in winter and 3-5 minutes in summer to cover the entire expected range of equivalent angular inaccuracy for distances of  $L = 75$  m. The experiment proceeds significantly faster when the distance  $L$  is greater. It is shown that measuring the time required for a spot to move across the measurement vertical is enough to determine the integral accuracy parameter of the mirror surface of an experimental heliostat. This time can be estimated visually or found more accurately from the readings of the transducers on the measurement vertical of the screen. References 4 Russian.  
[232-6900]

## STUDY OF RADIANT HEATERS WITH ELLIPTOCYLINDRICAL RADIANT ENERGY CONCENTRATORS

Tashkent GELIOTEKHNIKA in Russian No 2, Feb 84 (manuscript received 28 Sep 82) pp 30-35

PADERIN, L. Ya.

[Abstract] Radiant heaters with elliptocylindrical mirror concentrators and circular cylindrical radiation sources are analyzed parametrically. The radiant flux density on the collector is investigated. The incident radiant flux density on the focal line of a concentrator is calculated as an example. Figures 4, references 7 Russian.  
[232-6900]

MODELING OF SOLAR CONCENTRATORS

Tashkent GELIOTEKHNIKA in Russian No 2, Feb 84 (manuscript received 29 Sep 82) pp 26-30

ZAKHIDOV, R. A. and KLYCHEV, S. I.

[Abstract] The concentration field is modeled physically and mathematically to find the solar energy concentration and to determine the geometry of the reflecting surface in optical concentrating systems. The similarity criteria of the concentration field of mirror-type solar collectors are investigated. Figures 3, references 6 Russian.  
[232-6900]

NEW APPROACH TO DEVELOPMENT OF SELECTIVE SOLAR RADIATION CONCENTRATORS

Tashkent GELIOTEKHNIKA in Russian No 2, Feb 84 (manuscript received 24 Dec 82) pp 22-26

AFYAN, V. V. and VARTANYAN, A. V., All-Union Order of the Labor Red Banner Scientific Research Institute for Current Sources, Armenian Department

[Abstract] A new method is proposed for developing selective solar concentrators based on the use of holograms (diffraction gratings) to single out and concentrate a particular portion of the solar spectrum. The holographic concentrator is built by using a reference beam that is collimated and directed along the normal to the receiving surface of the light sensitive layer. The subject beam can vary, depending upon the type of holographic concentrator desired. Holographic concentrators can be made of inexpensive materials and represent a new class of solar concentrators with different designs providing extensive functional capabilities for use in direct conversion of solar energy to electricity. Holographic methods can also be used for selective coatings of solar collectors. Figures 3, references 7: 4 Russian, 3 Western.  
[232-6900]

UDC 662.997:662.93

INFLUENCE OF MERIDIONAL AND SAGITTAL ERRORS OF SURFACE OF PARABOLIC REFLECTOR ON ENERGY CHARACTERISTICS

Tashkent GELIOTEKHNIKA in Russian No 2, Feb 84 (manuscript received 24 Dec 82) pp 18-22

AVANESOV, E. S., BAUM, I. V. and MAMEDNIYAZOV, S. O., Solntse Scientific-Production Association, Ashkhabad

[Abstract] The focal concentration of solar concentrators is established analytically as a function of the mean square meridional and sagittal errors of the paraboloid. The analytical results are verified by a model of the operation of a parabolic reflector based on tracking the return path of the beam. The dimensionless focal concentration is calculated for a paraboloid with the same parameters as in the foregoing analysis. The simulation results agree well with the analytical findings. Figures 1, references 5 Russian.  
[232-6900]

UDC 662.997:537.22

CALCULATION OF PARAMETERS OF HIGH-POWER DUAL-MIRROR SOLAR FURNACES

Tashkent GELIOTEKHNIKA in Russian No 2, Feb 84 (manuscript received 24 Dec 82) pp 13-18

AZIMOV, S. A., AKBAROV, R. Yu., KULAKHMEDOV, N. N. and PIRMATOV, I. I., Physical-Technical Institute imeni S. V. Starodubtsev, Uzbek SSR Academy of Sciences

[Abstract] A method is proposed for determining several important characteristics of dual-mirror solar power plants. The calculation of the height-to-width ratio of a heliostat is investigated, along with the quantity  $\eta$ , which expresses the number of heliostats, tracking transducers, drives, etc. Specific recommendations for heliostat dimensions are derived by finding the shaded area of the heliostat as a function of the parameter  $\eta$ . Determination of the number of standard dimensions for facets required to obtain a concentrator surface that reproduces a paraboloid of revolution with the required accuracy is examined. Figures 4, references 6: 5 Russian, 1 Western.  
[232-6900]

UDC 621.382:621.383:621.472

SOME PROPERTIES OF HETEROJUNCTIONS IN ZINC TELLURIDE-CADMIUM TELLURIDE SYSTEMS

Tashkent GELIOTEKHNIKA in Russian No 2, Feb 84 (manuscript received 12 Feb 82) pp 6-8

RAZYKOV, T. M., INGMATOV, R. N., KHUSAINOVA, N. F. and PAK, A. T. Physical-Technical Institute imeni S. V. Starodubtsev, Uzbek SSR Academy of Sciences

[Abstract] The results of electrical and photoelectrical investigations of heterojunctions based on zinc telluride and cadmium telluride are presented. A proposed energy band model of the investigated structures is constructed. The band model is characterized by a higher potential barrier for base electrons than for holes in the surface barrier layer, and by the absence of discontinuities in the bands at the heterostructure interface, which is necessary for developing efficient photovoltaic cells. Figures 4, references 4: 2 Russian, 2 Western.  
[232-6900]

UDC 621.362:621.383.5(088.8)

INVESTIGATION OF THERMAL CHARACTERISTICS OF SEMICONDUCTOR HETEROSTRUCTURES EXPOSED TO CONCENTRATED SUNLIGHT

Tashkent GELIOTEKHNIKA in Russian No 2, Feb 84 (manuscript received 12 Feb 82) pp 3-6

MIRZABAYEV, M. M., RASULOV, K. KOMILOV, A. and TASHKHODZHAYEVA, S., Physical-Technical Institute imeni S. V. Starodubtsev, Uzbek Academy of Sciences

[Abstract] The degree of heating of photocell structures with a cooling device providing bilateral removal of heat from the cell for different levels of illumination is examined experimentally and theoretically to study physical processes occurring in photocell structures exposed to concentrated solar radiation. An equation for heat conductivity is derived that yields the temperature distribution in the photocell structure as a function of coordinate and time. The proposed construction for the cooling device provides effective removal of heat from the structure for solar radiation concentrations of up to 10,000. Figures 1, references 1 Russian.  
[232-6900]



SITUATIONAL PLANNING OF PRODUCTION PROCESSES IN A FLEXIBLE AUTOMATED PRODUCTION SYSTEM

Moscow VESTNIK MASHINOSTROYENIYA in Russian No 3, Mar 84 pp 47-50

SOLOMENTSEV, Yu. M., doctor of technical Sciences, BASIN, A. M., candidate of technical sciences and KLIMOV, S. V., engineer

[Abstract] The introduction of flexible automated production systems (GAPS) that reduce the number of machine tool workers and the product fabrication time also necessitates fundamentally new approaches to production process planning. This paper theoretically analyzes a proposed "situational planning system" (SIP) that takes full advantage of the capabilities of GAPS. The SIP system is a component of the automated control system for the GAPS, which in turn is subordinate to an integrated automated planning design and production engineering system. Depending on the production situation, requests are fed to the SIP system from the automated production process control system. Data on the production situation are also supplied simultaneously to the SIP system along with the request. While in the traditional approach to planning and manufacturing, a description of the routing-operational process of the production operations is fed into the production system or the automated control system for the GAPS, in the proposed case, only the production limitations are fed into the SIP system, i.e., to the automated control system for the GAPS, where these limitations include production process limitations (information on flow changes, possibilities for performing them by various production process means, etc.) as well as the organizational limitations (priorities of production batches, etc.). Information on the fabrication routing and the composition of the operations is generated by the SIP system, i.e., by the automated control system for the GAPS itself in real time. Thus, both the routing and composition of an operation become "flexible," while the control systems for the GAPS system becomes more "intelligent." The data model of the SIP system is represented as a set of data files, written in terms of the number of production batches, number of production blanks and parts, number of units in the largest batch, number of production process transitions and number of production process equipment units required. The production process limitations, containing four data files, are also described and the algebraic expression

of a portion of the control algorithm is adduced. It is argued that this approach substantially simplifies the long-term planning of production processes, providing for integrated design and production process engineering via the computer-aided design system. The construction of SIP algorithms is simulated for the case where three generalized operations on the data files are employed, enabling algebraic transcription of the algorithm, and thus design of a translator for these expressions, accelerating the computer running of the algorithms and also simplifying changing or amending of the SIP algorithms under specific production conditions. Repeated running of the algorithm for production simulation makes it possible to plan the production technology for poorly automated production operations. Figures 2, references 4: 2 Russian, 2 Western.  
[195-8225]

UDC 621.822:621.787.4

#### INFLUENCE OF SHOT-PEENING METHODS ON SURFACE QUALITY AND SERVICE LIFE OF BEARINGS

Moscow VESTNIK MASHINOSTROYENIYA in Russian No 3, Mar 84 pp 14-17

KUZNETSOV, N. D., academician, VOLKOV, V. I., candidate of technical sciences and DMITRIYEV, V. A., candidate of technical sciences

[Abstract] Since traditional strain hardening techniques (rolling with a ball or roller, diamond smoothing) are not feasible for finishing thin-walled, low stiffness annular parts with a complex surface configuration and small structural stress concentrators in the form of fillets and grooves, hydraulic shot peening is promising for such surfaces following polishing and superfinishing. Rolling contact bearing rings were subjected to abrasive hydraulic shot-peening using steel balls 1 to 2.4 mm in diameter made of ShKh15 steel (HRC 62-66) with transformer oil used as the fluid. The bearing races were also hardened with a working mixture of distilled water with anticorrosion additives, transformer oil and microscopic steel balls 63 to 300 micrometers in diameter. The effect of such treatment is evaluated by correlating the variations in the shot-peening apparatus parameters (working pressure at the ejector nozzle output, shot diameter, peening time) with the resulting roughness parameters, unevenness, microhardness and deviations from the correct shape. The hydraulic pressure ranged from 0.18 to 0.4 MPa and the treatment time from 15 to 60 s. The microhardness and residual stresses in the surface layer of the internal rings of 6-32205D1 rolling contact bearings were studied with x-ray diffraction analysis. The observed qualitative correlation between the decrease in the width of the x-ray interference line, the increase in the microhardness and in the residual compressive stresses indicates the relaxation of microstresses and the homogenization of the surface layer material following abrasive hydraulic shot-peening hardening or strain hardening with microscopic steel balls.

Tabular summaries of test stand data on 32118R2 roller bearings, strain hardened with microscopic steel balls, show that the service life of these bearings, with a damage probability of 10%, is 3.2 times greater than the corresponding life of the bearings after abrasive treatment; at a 50% damage probability, it is 2.53 times greater. Such shot-peening substantially enhances and stabilizes the surface quality of roller contact bearing races. Tables 5, figures 2, references 8 Russian.  
[195-8225]

UDC 621.9.044

#### FOCUSING OF SHOCK WAVES DURING MAGNETOHYDROIMPULSE LOADING

Kazan IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: AVIATIONNAYA TEKHNIKA  
in Russian No 4, Oct-Dec 83 (manuscript received 27 Dec 82) pp 92-94

KUVSHINOV, P. I. and KATAYEV, Yu. P.

[Abstract] Experiments are conducted to determine the pressure distribution over the surface of the deformed sheet blank during magnetohydroimpulse stamping. The distribution is found to depend upon the shape of the surface of the inductor that creates the electromagnetic field in the electrically conducting liquid. The experimental setup is described. Analysis of the results shows that the wave nature of the magnetohydroimpulse loading process is clearly defined even in the presence of an intermediate medium of a different type. Figures 8, references 2 Russian.  
[214-6900]

UDC 629.7.017.018.3

#### FUNDAMENTALS OF CONSTRUCTION AND USE OF CRITERIAL SIMILARITY MODELS FOR INVESTIGATING RELIABILITY AND QUALITY CONTROL OF COMPLEX ARTICLES

Kazan IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: AVIATIONNAYA TEKHNIKA  
in Russian No 4, Oct-Dec 83 (manuscript received 17 May 83) pp 57-68

SEVERTSEV, N. A., YARYGIN, G. A., SUKHANOV, A. V. and RAZIN, A. F.

[Abstract] A fundamental approach is proposed for developing methods of investigating the reliability and controlling quality of complex articles comprising systems and devices. The approach is based on similarity theory, which is used to select analogs of the articles being developed and to substantiate technical treatments by comparing the indicators achieved, expressed in criterial form, with the indicators of the basic future article. Common examples of the construction and use of criterial similarity models are presented. References 6 Russian.  
[214-6900]

UDC 621.983

FORMING AXISYMMETRIC PARTS FROM SHEET FOLLOWING FORMATION OF GROVE IN FLANGE OF BLANK

Kazan IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: AVIATIONNAYA TEKHNIKA  
in Russian No 4, Oct-Dec 83 (manuscript received 20 Nov 81) pp 26-30

GORBUNOV, M. N. (deceased) and ARKHANGEL'SKAYA, L. V.

[Abstract] The forming of axisymmetric parts by a rigid cylindrical punch and a rigid die is examined theoretically. It is found that forming by first gathering the material on the flange in the form of a groove can be very effective for obtaining axisymmetric sheet parts. Figures 3, references 2 Russian.

[214-6900]

UDC 620.193.621

INDUSTRIAL TESTS ON AST-500 MODEL OF MESH-TYPE HEAT EXCHANGER WITH TUBES MADE OF 08Kh14MF STEEL

Moscow TEPLOENERGETIKA in Russian No 3, Mar 84 pp 19-20

AFANAS'YEV, A. A., engineer, BORISOV, V. P., candidate of technical sciences, GREBENNIKOV, V. N., candidate of technical sciences, DOLININ, Ye. L., candidate of chemical sciences KRUTIKOV, P. G., candidate of chemical sciences, SHISHKUNOV, V. A., candidate of chemical sciences, and STOGOV, V. I., engineer

[Abstract] Industrial tests were performed on a model of mesh-type heat exchangers for atomic electric power and heating plants. The purpose of testing the AST-500 model of a heat exchanger separating the intermediate (second) loop from the last (third) loop was to confirm the selection of the technically and economically most suitable material for its tubes. The special-purpose 08Kh14MF ferritic-martensitic chromium steel had been proposed for this application, on account of its high corrosion resistance in aerated neutral media with a higher  $Cl^-$  content than in tap water. The model heat exchanger, with an effective surface area of 2 m<sup>2</sup> and weighing 350 kg, consisted of a frame made of St20 carbon steel with 12 tubes of St20 carbon steel in addition to 25 tubes of 08Kh14Mf steel (all tubes 1200 mm long with 16 mm outside diameter and 2 mm wall thickness). Its tubes were tested under a pressure of 16 MPa, carrying water at a rate of 14 t/h at temperatures from 70 to 90°C. Pitting was found to be the dominant mode of corrosion, most intense at 90°C, but not imminently dangerous. The results of chemical and phase analysis by nuclear-gamma resonance spectrometry revealed the presence of iron oxides in the scale. Uniform corrosion of this material at a rate not higher than 0.003 mm/yr should not degrade the performance of heat exchangers under normal conditions during the expected service life. Table 1, references 4 Russian.

[200-2415]

## EFFICIENCY OF PROGRAMMED MOTION CONTROL SYSTEMS

Leningrad IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: PRIBOROSTROYENIYE  
in Russian Vol 27, No 5, May 80 (manuscript received 21 Sep 83) pp 82-88

BESEDIN, V. M., Moscow Institute of Power Engineering

[Abstract] The problem of digital program control for machine tools is considered from the standpoint of efficiency and its dependence on the accuracy of scan trajectories. An overlap of neighboring scan loops will decrease the effect of trajectory inaccuracy, with three algorithms of scanning possible: 1) scan time and scan rate fixed independently of the overlap ratio, but width of sweep zone depending on the overlap ratio; 2) sweep zone and scan rate fixed, but scan time increasing with larger overlap; 3) sweep zone and scan time fixed, but scan rate increasing with larger overlap. Each algorithm yields a payoff in either detection probability or scan time. The overall detection probability is defined as

$$P_i = Q\{\bar{x}, \phi_i \bar{x}\} \left[ \int_{S_j} f(\bar{x}) dx - P_{mh,j} \right] \quad (i = 1, 2, 3 - \text{number of algorithm}, j = 1$$

for first algorithm,  $j = 2$  for second and third algorithms,  $Q$  - local efficiency function determining the conditional detection probability). The scanning process is particularized for the two most common scan trajectories: meander and rectangular spiral in a plane with the number of loops ranging typically from 2 to 8. Calculations, with the aid of a numerical table, reveal the relation between the number of possible trajectory executions and the width (variable or uniform) of the unscanned zone for any given odd or even number of loops and absolute deviation of the center of the scan pattern. The missed-hit probability is found to be inversely proportional to the width of the corresponding directional diagram in the case of narrow diagram ( $\alpha \leq 4'$ ) and large trajectory errors ( $\sigma > 1'$ ), assuming a normal distribution of the latter. The detection probability is found to decrease with increasing overlap ratio, faster during a meander scan than during a spiral scan. The detection probability remains high, decreases slightly, or decreases appreciably, as the overlap ratio is increased, depending on whether scanning proceeds according to the second, third, or first algorithm respectively. The control program can, on this basis, be optimized for any specific application. Article was recommended by Department of Automation. Figures 4, references 4 Russian.  
[239-2415]

## MODEL OF TRIGGER-TYPE SPEED REGULATOR WITH DISTRIBUTED MOMENTUM AND FLUCTUATING PARAMETERS

Leningrad IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: PRIBOROSTROYENIYE  
in Russian Vol 27, No 5, May 80 (manuscript received 23 May 83) pp 68-72

BAUTIN, N. N., KOMRAZ, L. A., UKRAINSKIY, B. S. and CHERNYAGIN, B. M.,  
Gorkiy Institute of Water Transportation Engineers

[Abstract] A trigger-type speed regulator with linear hair spring and with time distribution of momentum is considered in which transfer of energy for compensation of losses occurs not instantaneously but over a time interval while the balance wheel hunts the momentum vector angle. Such a regulator is regarded as an oscillator and the corresponding equations of motion with instantaneous velocity jump are formulated in dimensionless variables. Central symmetry (with respect to the origin of coordinates in the phase portrait) of the phase trajectories beyond the momentum zone is taken into account so that the equation of phase trajectories in only one quadrant needs to be derived, this equation describing trajectories between two singularities and generating a periodic solution of the problem. Relations are established on this basis for four performance parameters ( $Q$ -factor, natural frequency  $\omega_0$ , dispersion of the amplitude  $R_0$ , dispersion of the daily travel  $S_0$ ) as functions of five design parameters (moment of inertia of balance wheel  $J$ , stiffness of hair spring  $\kappa$ , friction coefficient  $k$ , impact coefficient  $\alpha^0$ , torque  $P^0$ ) allowing  $J$  and  $\kappa$  to fluctuate while  $\alpha_i$  and  $P_i$  remain mutually independent stationary  $\delta$ -correlated sequences with known mathematical expectations  $M[\alpha_i] = \alpha^0$  ( $0 < \alpha^0 \leq 1$ ) and  $M[P_i] = P^0 / \kappa$  ( $i = \dots, -1, 0, 1, \dots$ ) respectively. Curves of  $Q$ ,  $\omega_0$ ,  $R_0$ ,  $S_0$  are plotted in the  $J$ - $\kappa$  plane for a fixed  $P^0$  and found to intersect all at one point corresponding to  $J_0$ ,  $\kappa_0$ . These curves indicate design and performance tradeoffs. Article was recommended by Department of Higher Mathematics. Figure 1, references 4 Russian. [239-2415]

TURBINE AND ENGINE DESIGN

UDC 621.165:621.18.08.001.42

DEVICE FOR MEASURING RELATIVE AXIAL EXPANSION OF TURBINE ROTOR EMPLOYING SPACE-VECTOR TRACKING METHOD

Moscow ELEKTRICHESKIYE STANTSII in Russian No 3, Mar 84 pp 27-29

KAPINOS, V. M., doctor of technical sciences, KUSENKO, V. A., ZARUBIN, L. A., ZIMICHEV, Yu. I., ZYUZ'KIN, V. G., LYAKHOV, F. Ya, PALEY, V. Z., candidate of technical sciences, TKACHENKO, M. D., FESENKO, V. D. and KHRESTOVOY, Yu. L., candidate of technical sciences

[Abstract] A new device for measuring the relative axial expansion of turbine rotors is described that overcomes the deficiencies of the devices now in use and has good metrological properties. The parameters of the new device are analyzed through laboratory tests that indicate its suitability for new as well as existing turbines. Figures 3, references 4 Russian.  
[215-6900]

UDC 62-226.001.5

USE OF LEAST-SQUARES METHOD FOR ESTIMATING ERRORS OF TURBINE BLADE TYPE PARTS DURING FABRICATION

Kazan IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: AVIATSIONNAYA TEKHNIKA in Russian No 4, Oct-Dec 83 (manuscript received 25 Feb 83) pp 102-104

KHLOPOTOV, O. D., BOCHKOV, I. S. SKORODUMOVA, Ye. S and TRIFONOV, L. M.

[Abstract] This study demonstrates the application of least squares methods to ensure that the accuracy of turbine blades and similarly shaped articles is in accordance with existing standards for the deviation of linear and angular dimensions, and that the position of each section with respect to the base employed is precise. Figure 1, reference 1 Russian.  
[214-6900]

UDC 519.237.5

PREDICTING CHANGES IN RELIABILITY CHARACTERISTICS OF GAS TURBINE ENGINES  
DURING OPERATION

Kazan IZVESTIYA VYSSHIKH UCHEBNIKH ZAVEDENIY: AVIATIONNAYA TEKHNIKA  
in Russian No 4, Oct-Dec 83 pp 68-72

CHEPRASOV, V. P. and VULIKH, Ye. Ts.

[Abstract] A procedure is described for predicting possibility estimates of failures in individual gas turbine engines, and an algorithm is described for predicting changes in the conditional probabilities of occurrence of failures of each engine in a pool, allowing for operating conditions.  
[214-6900]

UDC 621.45.00.11

OPTIMUM THERMOGASDYNAMIC DESIGN OF GAS TURBINE ENGINES BY CHARACTERISTICS  
OF ELEMENT PROTOTYPES

Kazan IZVESTIYA VYSSHIKH UCHEBNIKH ZAVEDENIY: AVIATIONNAYA TEKHNIKA  
in Russian No 4, Oct-Dec 83 (manuscript received 19 Apr 83) pp 35-41

KOZHEVNIKOV, Yu. V., BOROVIK, V. O. IVANOV, V. S., TALYZIN, V. A.,  
AGLIULLIN, I. N. and MELUZOV, Yu. V.

[Abstract] Formulas are derived to provide graphic approximations of assigned characteristics of components including low- and high-pressure compressors and blowers. The parameters of a two-stage aircraft engine are optimized.  
Figures 4, references 5 Russian.  
[214-6900]

UDC 539.434

LONGEVITY OF THIN-WALLED ENGINE PARTS SUBJECTED TO TRANSIENT STRESSES UNDER  
CREEP CONDITIONS

Kazan IZVESTIYA VYSSHIKH UCHEBNIKH ZAVEDENIY: AVIATIONNAYA TEKHNIKA  
in Russian No 4, Oct-Dec 83 (manuscript received 9 Feb 83) pp 31-35

GUROV, A. F., TOKAREV, V. D. and KOMKOV, V. A.

[Abstract] The longevity of a part subjected to monotonically increasing stress from zero to breakdown is examined. Formulas are derived to describe the vulnerability and longevity of thin-walled structural members under varying conditions of monotonically increasing stress. Figures 3, references 4 Russian.  
[214-6900]



## RANDOM VIBRATIONS OF AIRCRAFT ENGINE BLADES

Kiev PROBLEMY PROCHNOSTI in Russian No 1, Jan 84 (manuscript received 21 Oct 82)) pp 65-67

GERSHGORIN, A. D. and KEMPNER, M. L., Moscow

[Abstract] A simple model of an aircraft engine blade with long stem and dry-friction damping is considered for analysis of flexural vibrations in the plane of rotation under a dynamic load. The blade is treated as a cantilever beam, its mass is lumped at the free end, and the dynamic load is replaced by a centrifugal force acting at the free end as a stationary centered random process. The corresponding equations of motion are solved by the method of statistical linearization, which yields the mean value and the dispersion of flexural stress. Calculations are done for the special case of a blade with uniform stiffness and a "white noise" perturbation force with infinite spectrum. First considered is a blade without damper and thus motion with one degree of freedom, then a blade with damper at the center and thus motion with two degrees of freedom. In the latter variant the damper is assumed to have a lumped mass equal to that of the blade. The results indicate ways to optimize the damping of random blade vibrations. Figures 4, references 7 Russian.  
[199-215]

TERMINAL CONTROL OF GLIDING IN ATMOSPHERE

Kazan' IZVESTIYA VYSSHYKH UCHEBNYKH ZAVEDENIY: AVIATSIONNAYA TEKNIKA, in Russian No 5, Oct-Dec 83 (manuscript received 14 Feb 83) pp 3-9

AFANAS'YEV, V. A. and SIRAZETNIVOV, T. K.

[Abstract] The problem of controlling gliding of a flight vehicle entering the atmosphere at near-circular velocity and landing at a specified point on the ground is examined. Control is accomplished by changing the angular orientation of the flight vehicle by the moments of the forces created by the engines and applied perpendicular to the longitudinal axis. Changing the angular orientation of a flight vehicle changes the trajectory of its center of mass. An example of the simplified control problem is presented in which crude assumptions are refined through iterative synthesis of the control force. Figures 2, references 3 Russian.  
[214-6900]

UDC 535.315

DESIGN OF TWO-MIRROR SCANNER WITH AXES OF ROTATION NOT IN PLANE OF MIRRORS

Leningrad OPTIKO-MEKHANICHESKAYA PROMYSHLENNOST' in Russian No 2, Feb 84  
(manuscript received 15 Mar 83) pp 29-31

ANTONOV, Ye. I., TKACHEV, A. and RIDIGER, V. V.

[Abstract] Design equations are derived for a pair of rotating wedges as scanner mirrors. Any spiral or rosette trajectory of the light spot can be achieved with the proper speed ratio and senses of rotation. Aberration, caused mainly by chromatism, is eliminated by rotating the mirrors about axes not in their plane but parallel to one another. Calculations are shown for a typical configuration in a stationary reference system of Cartesian coordinates. The light path with reflections and the light spot trajectory on the target are calculated by the reflections and the light spot trajectory on the target are calculated by the matrix method, assuming that each wedge constitutes a plane mirror. A spiral trajectory inscribes an elliptical field with variable pitch when the speed ratio  $C$  lies with the  $1 < C < 2$  range, but the field approaches a circular one as the angle between light path and axes of rotation increases. The maximum pitch of the spiral trajectory and the allowable divergence angle of the light beam each determine the other, both also depending on the speed ratio. Design and performance calculations made on a Besm-6 high-speed computer are shown for  $C = 1.05$  and  $C = 1.3$  with a  $\theta = 0.66^\circ$  angle between the axes of rotation and normals to the mirror surfaces. Figures 3, references 3 Russian.  
[235-2415]

UDC 535.317.2

EFFECT OF ABERRATION IN OPTICAL SYSTEM ON ILLUMINANCE DISTRIBUTION OVER IMAGE OF STRIP IN SEMICOHERENT LIGHT

Leningrad OPTIKO-MEKHANICHESKAYA PROMYSHLENNOST' in Russian No 2, Feb 84  
(manuscript received (manuscript received 18 May 83) pp 27-29

PEYSAKHSON, I. V., and MAL'TSEV, N. M.

[Abstract] The effect of third-order aberration on the image of a transparent strip is analyzed systematically, characteristics of this aberration being indicators of technological imprecision and errors. The analysis involves a comparative evaluation of illuminance profiles corresponding to various

degrees of noncoherence. Calculations are shown for condenser and objective lenses in circular frames, assuming a uniform luminosity of the condenser pupil. They are based on Hopkins relations. Both wave aberration and spherical aberration are considered, coma, astigmatism, and defocusing being determined in each case. The results reveal that coma with its axis of symmetry parallel to the image axis causes least widening of the image, while defocusing being determined in each case. The results reveal that coma with its axis of symmetry not parallel to the image axis produces an asymmetry of the illuminance profile, with maximum illuminance shifting away from the center as the angle between coma axis and image axis increases from 0 toward 90°. Figures 3, references 8: 4 Russian, 4 Western.  
[235-2415]

UDC 532-783.81

#### MEASUREMENT OF PARAMETERS DEFINING ORIENTATION OF LIQUID CRYSTALS IN ELECTRO-OPTIC CELLS

Leningrad OPTIKO-MEKHANICHESKAYA PROMYSHLENNOST' in Russian No 2, Feb 84  
(manuscript received 24 March 83) pp 19-21

KORZHENEVSKIY, V. A., LEBEDEV, V. I., LEVICHEV, S. A. and TIMILIN, M. G.

[Abstract] Liquid crystals with smooth nonoriented surfaces have either homeotropic or planar orientation, depending on whether their surface tension is respectively larger or smaller than the critical surface tension of the substrate. An experimental method of determining both parameters has been developed for the purpose of predicting the orientation of real crystals with nonideal surfaces. The surface tension of the liquid crystal is determined from measurement of the distance  $x$  between two points on the meniscus far from the container wall that correspond to two distinctly different reflection angles:  $\sigma_{\text{liq. cryst.}} = Ax^{2\phi} + B$  ( $\phi$  - density of liquid crystal,  $A$  - design constant,  $B$  - correction term). The instrumentation for this measurement includes a laser source, a mirror, a diaphragm, a lens, and a movable stage with micrometer screw. The critical surface tension of the substrate is determined from measurement of the force acting on a thin plate coated with the orientant material and originally edgewise immersed in a nonpolar reference liquid, as this plate separates from the free surface of that liquid upon being pulled out, and measurement of the interphase tension minus free adhesion at that instant. The instrumentation for these measurements consists of a spring scale. The method was tested on six liquid crystals with different compositions based on azoxy compounds, cyanobiphenyls, tolans, or bicyclooctanes, with an orient coating of polythyl hydrosiloxane (GK-94 fluid), organosilicon-based compound, or polyimide resin on the plate. Measurements were made at temperatures from -15°C to +54°C. The authors thank P. V. Adomenas at Vilnius State University for producing the liquid crystals. Figures 3, tables 2, references 8: 4 Russian, 4 Western.  
[235-2415]

## METHOD OF PRECISE DETERMINATION OF POLARIZING POWER OF POLARIZERS

Leningrad OPTIKO-MEKHANICHESKAYA PROMYSHLENNOST' in Russian No 2, Feb 84  
(manuscript received 17 May 83) pp 12-14

KRUGLYAKOVA, M. A. and VOROB'YEV V. G.

[Abstract] A method of precise determination of the polarizing power of polarizers has been devised for spectrophotometry in polarized radiation, involving measurement with a pair of polarizers. The ratio and the product of two polarization degrees are measured, the ratio with an auxiliary polarizer before the entrance slit and the product without this auxiliary polarizer but with two of the pair oriented successively in four different ways relative to the monochromator slit (both perpendicularly to the slit, both parallel to the slit, the two crossed with alternately each "along the light path"). The polarizing power of each polarizer is then calculated from the matrix of readings, within the tolerance matrix of errors relative to spectrophotometer sensitivity, on the basis of equations that relate transmission factors and polarization degrees in the system. Numerical data are given for polarizer gratings on AgBr, on Teflon, and on polyethylene respectively, also results of measurements in an RYe-580 infrared spectrophotometer with three film polarizers of the same kind. A comparative evaluation of this method and the Rupprecht-Ginsbery-Leslie method indicates that the proposed one here is 2-7 times more accurate. Tables 3, references 9: 5 Russian, 4 Western.  
[235-2415]

## CALCULATION OF REFLECTION COEFFICIENT FOR TRIHEDRAL-CORNER REFLECTOR WITH NONSPECULAR FACETS

Leningrad OPTIKO-MEKHANICHESKAYA PROMYSHLENNOST' in Russian No 2, Feb 84  
(manuscript received 25 Feb 83) pp 10-12

VARSHAVCHIK, M. L.

[Abstract] The reflection coefficient  $\rho_0$  for a symmetric trihedral-corner reflector with triangular facets and an entrance hole is calculated as the ratio of luminous flux reflected through that hole to luminous flux impinging on it. The inside surfaces are assumed to obey Lambert's law with a reflection coefficient  $\rho$ . A relation is derived according to which the ratio  $\rho/\rho_0$  is a linear function of  $P$  and a more intricate function of the angle  $\phi_f$  between facets. This relation was verified experimentally for a  $4^\circ$  angle between direction of incident flux and bisector of the reflector angle with  $P$  varied over the 0.06-0.9 range. The results are used to plot the back-scattering indicatrix of such a reflector, with a  $45^\circ$  angle

resolution,  $\log(\beta \cos \phi) = f(\phi)$  over the  $0 \leq \phi \leq 90^\circ$  range, where the brightness coefficient is  $\beta(\phi) = \beta_e(\phi) + \beta_i(\phi)$  e- external component, i- internal component). The author thanks M. A. Kladenskaya for assistance. Figures 2, references 4: 3 Russian, 1 Western.  
[235-2415]

UDC 535+621.373.8

#### AFOCAL ATTACHMENT FOR COLLIMATION OF LASER BEAM

Leningrad IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: PRIBOROSTROYENIYE  
in Russian Vol 27, No 5, May 84 (manuscript received 10 Nov 82) pp 93-96

ANDREYEV, L. N., NIKIFOROVA, G. L., OKISHEV, S. G., PEROV, I. Yu. and  
FILIMONOV, A. A., Leningrad Institute of Precision Mechanics and Optics

[Abstract] A galilean telescope with  $180^\circ$  inversion is proposed for reducing the divergence of laser beams, its important advantage being the absence of an intermediate real image and consequently of an energy concentrator inside the optical system. Design and performance of such a collimator are analyzed in terms of geometrical dimensions and optical aberration, respectively, assuming a homocentric laser beam so that only spherical aberration needs to be corrected and in the region of its third order only. From this standpoint the authors calculate the necessary focal lengths of a thin plano-concave lens as first component and of a pair of thin plano-convex lenses as second component, then the distance between components, and finally the magnification. Three possible configurations of the second-component lens pair are considered: 1) convex side of second facing plane side of first; 2) convex sides of both facing each other; 3) plane side of second facing convex side of first. The refractive index of glass is given for violet light and for red light as well as at an intermediate wavelength. On this basis, an afocal collimating system is designed with a residual spherical aberration at all three wavelength over the visible range not exceeding a few angular seconds and also without coma. With a given pair of lenses for the second component, one can optimize this collimator by selecting the best mutual orientation and varying the first-component focal length. Article recommended by Department of Optical Instruments. Figure 1, tables 3, references 5 Russian.  
[239-2415]

## INTERFERENCE IMMUNITY OF OPTOELECTRONIC SYSTEM WITH RASTER COMBINING PULSE-WIDTH AND PULSE-TIME MODULATION

Leningrad IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: PRIBOROSTROYENIYE in Russian Vol 27, No 5, May 84 (manuscript received 6 Oct 83) pp 89-92

KAZAKOV, V. A. and SHUMOV, A. P., Ryazan Institute of Radio Engineering

[Abstract] An optoelectronic instrument with a raster that combines pulse-width and pulse-time modulation is considered for determining the coordinates of small objects. The analysis of its performance is based on the Markov theory of nonlinear filtration for quasi-coherent reception of quasi-square pulse signals. The raster is a wheel with identical tapered teeth that during rotation chop the image signal from an object smaller than a slot located above the wheel axis into a pulse sequence. Vertical motion of the object modulates the duration of these pulses and horizontal motion of the object modulates the time position of these pulses. Interference includes, in addition to the intrinsic noise of the radiation power receiver, either fluctuation of the radiation incidence angle, signal fading, and correlated additive background noise or, in the absence of other interference, also wideband white noise. For evaluation of the instrument accuracy, the latter is characterized by stationary dispersions of a posteriori and extrapolated distributions. These indicators are calculated as functions of pulse squareness factor, pulse duty factor, and signal-to-noise ratio for each kind of interference. The results reveal that the horizontal component of target deviation is determined more accurately than its vertical component, this difference in accuracy being a major drawback of image analysis with a combined-modulation raster. Signal fading, characterized by a log normal distribution of signal amplitude, is not detrimental to the instrument accuracy when the jitter (fluctuation of the incidence angle) remains small. Article recommended by Department of Radio Control and Communication. Figures 4, references 4 Russian. [239-2415]

UDC 537.533.3

## DESIGN AND EVALUATION OF LIGHT-VALVE PROJECTORS FOR PLAYBACK OF PHASE-RECORDED OPTICAL IMAGE

Leningrad IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: PRIBOROSTROYENIYE in Russian Vol 27, No 5, May 84 (manuscript received 12 Dec 83) pp 73-82

ODINTSOV, S. L., ROZHKOV, O. V., SHCHETINKIN, V. S. and FEDOROV, Yu. V., Moscow Higher Technical School imeni N. E. Bauman and Leningrad Institute of Precision Mechanics and Optics

[Abstract] The theory of phaseoptical recording and light-valve projecting is reviewed with the conclusion that, although the Zernike method provides the

simplest function transformation with high contrast and while the defocusing method is most easily implementable but involves an intricate function transformation process with low contrast, only the dark-field method ensures high contrast independently of the source's degree of space coherence with a viewing diaphragm that covers the source's image without phase recording. The performance of a projector objective in a dark-field light-valve system is evaluated, taking into account shielding of the first-order diffraction and consequent reduction of the luminous flux. The problem of performance and design optimization is treated on the basis of the integral light-modulation characteristic, using the Fraunhofer luminosity function and the maximum optical efficiency as indicators. Several projectors operating according to this method have been developed and built: "Rastr", "Tsilindr", "Prizma", "Kvadrat-15", "Gel'-3" with nonvarying orientation of the space carrier (code letters ShS), "Telegrafnyy", "Snezhinka" for regular recording without grating; "Gel'-1", "Foton" with space carrier and varying grating orientation (code letters ShP, ShS); "Plastikon", "Plastikon-2" for irregular or micro-funnel recording. The design of most is governed by the phaseoptical recording system, except the design of "Rastr" and "Foton" as well as of "Mikro-4" with thermoplastic film structurally separate from the imaging system. The screen dimensions vary widely, depending on the application, screens for collective viewing in high-intensity light being particularly difficult to design. Used as hot light sources are preferably super-high-pressure lamps DRSh (mercury) and DKsSh (xenon), also K, OP, and KGM (halide) lamps, with either parallel or convergent light beam. Laser sources offer the advantage of no heating but yield images with "speckle structure". Article was recommended by Department of Theory of Optical Devices. Figures 4, tables 2, references 17 Russian.

[239-2415]

UDC 621.384.6

#### SMALL SHAPER OF ELECTRON BEAM FOR BOMBARDMENT WITH ACCELERATED ELECTRONS

Moscow ATOMNAYA ENERGIYA in Russian Vol 56, No 5, May 84  
(manuscript received 31 Jan 83) pp 311-313

GUSEV, O. A., DMITRIYEV, S. P., IVANOV, A. S., OVCHINNIKOV, V. P.,  
SVIN'IN, M. P. and FEDOTOV, M. T.

[Abstract] A method has been proposed for correcting the trajectory of electrons in high-voltage accelerators so as to ensure a nearly normal incidence on the target foil. A deflecting d.c. electromagnet is placed immediately before the exit window, while limiting the scan angle to 85° maximum allows the height of the scan chamber to be reduced and a corrective electromagnet serves as beam width transformer. The deviation of the electron incidence angle from 90°, which is otherwise approximately equal to half the scan angle, can be eliminated by appropriate distribution of the magnetic field in the inter-polar space or by tapering the pole height longitudinally. Uniform distribution of the magnetic field requires that the waveform of the current in the scanning electromagnet coils not be a sawtooth, in which case the scan rate



varies as an inverse sine-squared function of the scan angle, but shaped so as to ensure constant scan rate and uniform linear current density. The feasibility of such a device has been proved experimentally with an axisymmetric 18 kW beam of 300 keV electrons. With scanning angle of 5-20° and +8% fluctuation of the linear current density over a distance of 1200 mm, electrons entered the target foil within  $7 \pm 0.5^\circ$  about the normal. Figures 2, references 9: 7 Russian, 2 Western.  
[234A-2415]

UDC 621.3.038.612

#### NEW GENERATION OF MULTIPLE-CHARGE ION SOURCES (REVIEW)

Moscow ATOMNAYA ENERGIYA in Russian Vol 56, No 5, May 84  
(manuscript received 1 Aug 83, final edition received 2 Jan 84) pp 303-310

GOLOVANTIVSKIY, K. S.

[Abstract] The only type of ion source available for heavy-ion accelerators until the nineteen seventies, the PIG Penning reflective discharger with oscillating electrons, is now followed by a new generation of multiple-charge ion sources. First among them are the EBIS Electron-Beam Ion Source, originally invented by Ye. D. Donets (Joint Institute of Nuclear Research, Dubna) in 1967, and its latest most perfect KRION-2 Cryogenic Ionizer modification. Next comes a laser, particularly a CO<sub>2</sub>-laser ( $\lambda = 10.6 \mu\text{m}$ ), short periodic radiation pulses impinging on a small metal target. Sources of the third group operate on the basis of electron-cyclotron resonance. In sources of the ECR-M type (Machines à Faire Ions Strippées: MAFIOS, superhigh-power SUPERMAFIOS, optimized miniaturized MINIMAFIOS) plasma is contained in a mirror trap and microwave heating of its electron component up to cyclotron resonance is effected in the attendant magnetic well. Sources of the ECR-H type (Hot-Electron Layer Ion Source: HELIOS and its latest version HELIOS-12A) utilize the radial profile of ambipolar electric potential forming a potential well for ions during electron-cyclotron resonance. Figures 6, tables 3, references 47: 12 Russian, 35 Western.  
[234A-2415]

FLUID MECHANICS

UDC: 534.26

DIFFRACTION OF SPHERICAL WAVE ON ROUGH SPHERE

Moscow AKUSTICHESKIY ZHURNAL in Russian Vol 30, No 1, Jan-Feb 84  
(manuscript received 2 Aug 82) pp 96-99

POPOV, Yu. Yu., SKIPA, M. I. and FISHKOV, F. A., Odessa Department,  
Marine Hydrophysical Institute, Ukrainian SSR Academy of Sciences

[Abstract] A modified method of small perturbations is used to find the average field of a spherical wave scattered on a rough sphere. In contrast to the solution obtained by the sequential approximation method, the approach employed makes it possible to determine the influence of the irregularity on attenuation of the wave enveloping the sphere. References 10: 5 Russian, 5 Western.

[223-6900]

UDC: 539.3:534.242

RESONANT SCATTERING OF ACOUSTIC WAVES BY ELASTIC SPHERICAL SHELL IN FLUID

Moscow AKUSTICHESKIY ZHURNAL in Russian Vol 30, No 1, Jan-Feb 84  
(manuscript received 18 Mar 82) pp 89-95

PODDUBNYAK, A. P., Institute of Applied Problems of Mechanics and  
Mathematics, Ukrainian SSR Academy of Sciences

[Abstract] The theory of resonant acoustic scattering is employed to examine the fine structure of the spectrum of echo signals reradiated by a thin elastic hollow spherical shell. Comparative numerical analysis confirms the applicability of the theory of Timoshenko-type shells in steady-state and transient modes for a wide range of variation of the wave parameters of a thin-walled object. The explicit analytical formulas derived for resonant parameters using the R-matrix approach makes it possible to understand the mechanism underlying the formation and structure of reradiated signals. Figures 4, references 21: 15 Russian, 6 Western.

[223-6900]

UDC: 534.21

DISPERSION CURVES FOR NORMAL WAVES IN CYLINDRICAL SHELL AND CONDITIONS FOR  
SPATIAL COINCIDENCE IN VICINITY OF CRITICAL FREQUENCIES

Moscow AKUSTICHESKIY ZHURNAL in Russian Vol 30, No 1, Jan-Feb 84  
(manuscript received 23 Jul 82) pp 83-88

MUZYCHENKO, V. V., PANIKLENKO, A. P. and RYBAK, S. A., Acoustics Institute  
imeni N. N. Andreyev, USSR Academy of Sciences

[Abstract] The eigenfrequency spectrum of a cylindrical shell with incident plane wave in a liquid is analyzed. The behavior of the dispersion curves for normal waves in an infinite thin cylindrical shell is examined. The spatial coincidence conditions are analyzed for quasi-flexural, quasi-shear and quasi-longitudinal waves occurring with incidence of a plane acoustic wave at an arbitrary angle. Analytical expressions are derived for the frequencies and angles of spatial coincidence in the vicinity of the critical frequencies of the shell. Figures 4, references 4 Russian.  
[223-6900]

UDC: 533.6.011.8

AERODYNAMIC AND THERMAL CHARACTERISTICS OF STELLATE BODIES IN HYPERSONIC FLOW  
OF RAREFIED GAS AT ANGLE OF ATTACK

Moscow VESTNIK MOSKOVSKOGO UNIVERSITETA SERIYA 1: MATEMATIKA, MEKhanika  
in Russian No 2, Mar-Apr 84 (manuscript received 25 Aug 82) pp 74-77

BUNIMOVICH, A. I. and KUZ'MENKO, V. I.

[Abstract] The aerodynamic and thermal characteristics of stellate bodies are assessed for varying members of rays, relative thickness, flight altitude and angle of attack; graphs are developed that can be used to select the optimum configuration for a specific problem. Figures 2, references 6 Russian.  
[217-6900]

# INTENSIFICATION OF CONVECTIVE HEAT TRANSFER BY MEANS OF ARTIFICIAL SURFACE ROUGHNESS

Moscow TEPLOENERGETIKA in Russian No 3, Mar 84 pp 10-14

ZHUKAUSKAS, A. A., academician, LSSR Academy of Sciences

[Abstract] Artificial roughness is considered as passive means of intensifying convective heat transfer from a wall to a turbulent stream, intensification in this case being a consequence of a boundary layer with lower thermal resistance rather than of a larger effective surface area. The mechanism is analyzed on the basis of velocity profiles through the laminar sublayer, the transitional interlayer, and the logarithmic turbulent core. The velocity profiles are obtained from the solution of the corresponding equation of one-dimensional heat transfer, taking into account total as well as molecular heat conduction. Theoretical and experimental data on plates and pipes with cooling air, water, or transformer oil have been evaluated at the Institute of Physicotechnical Problems in Power Engineering (LSSR Academy of Sciences), in terms of the Nusselt number as function of both the Reynolds number and the Prandtl number and with the velocity of the stream normalized to a characteristic parameter with the dimension of velocity: square root of the ratio of shearing stress to density. In the case of pipes, inside and outside cooling have been considered. The results indicate how the roughness characteristics, namely surface profile and asperity height, and the Prandtl number at fixed values of the Reynolds number can be optimized for maximum heat transfer intensity. Figures 7, table 1, references 12: 7 Russian, 5 Western. [200-2415]

# TRANSSONIC FLOW OF ELASTIC MEDIUM PAST SLENDER SOLID BODY

Moscow PRIKLADNAYA MATEMATIKA I MEKhanika in Russian Vol 48, No 1, Jan-Feb 84 (manuscript received 30 Nov 81) pp 114-122

SIMONOV, I. V., Moscow

[Abstract] Frictionless transsonic flow of a boundless elastic medium past a perfectly rigid slender flat solid, a blade of symmetric cross section and finite length  $L$ , is analyzed in terms of velocity and stress fields. The boundary conditions are zero transverse displacement before the blade tip, zero transverse stress behind the blade base, and zero shearing stress throughout. Also stipulated are nonseparation flow without tensile stress along the blade surface, separation occurring at the base joint without intersection of the cavity wall in the wake and the blade contour behind the separation. The blade profile is assumed to widen monotonically from tip to base and the energy density within any finite volume of the fluid medium is assumed to be integrable. The condition of radiation is added as another

constraint. The corresponding two-dimensional steady-state problem is formulated in accordance with the theory of elasticity, with displacements expressed through potentials. The solution of the corresponding Hilbert problem is sought in the class of functions with upper bounds  $\text{const}/\sqrt{|z|}$  and  $\text{const}/\sqrt{|z - L|}$  at blade tip and blade base respectively. The behavior of the solution at these singular points as well as at infinity is analyzed. Taking into account existence of transverse waves. Two theorems are stated and proved pertaining to smooth separation, on the basis of which the a priori unknown point along the blade contour at which separation begins can be located. Two other theorems are stated that generalize the condition for smooth separation and extend separation to a three-dimensional transient-state problem. Figure 1, references 12: 10 Russian, 2 Western. [236-2415]

UDC 621.822.5.033

#### STABILITY OF LUBRICANT FILM IN GAS DYNAMIC BEARING

Leningrad IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: PRIBOROSTROYENIYE in Russian Vol 27, No 5, May 84 (manuscript received 28 Nov 83) pp 63-68

AREF'YEV, B. A., GULYAYEV, K. I. and TALAYKOVA, N. B., Leningrad Institute of Precision Mechanics and Optics

[Abstract] The stability of a gas stream between two cylindrical rotating surfaces, one inside the other, is analyzed from the standpoint of a gas dynamic bearing. Particularly important is consideration of flow of a thin lubricant film with a low Reynolds number. The corresponding differential equation for the circumferential pressure distribution is formulated in a polar system of coordinates fixed to and rotating with the shaft so that the pressure on the shaft as well as the angular coordinate of a stationary point of the bearing become periodic functions of time. The equations of state for the lubricant film remain conventional in form, with the angular coordinate correspondingly changed to the product of time by the constant angular velocity. The problem is solved upon introduction and evaluation of the "characteristic index" containing an integral resolvable into two parts. The first part is always positive and has always a destabilizing effect. Only the second part, which depends on the shaft eccentricity and the pressure distribution function, can contribute to stability of the lubricant film. The condition for stability is established as an upper bound on the product of pressure amplitude and compressibility number. This upper bound is proportional to the sine of the pressure phase angle and a third-degree polynomial function of the shaft eccentricity, which indicates that, even at a low Reynolds number, stable steady flow of a gaseous lubricant is not possible and vortices will build up unless the eccentricity is larger than critical. Article was recommended by Department of Precision Mechanical Devices. Figure 1, references 11: 5 Russian, 6 Western. [239-2415]

# LINEAR PROBLEM OF HARMONIC VIBRATOR ACTING AT SUPERCRITICAL FREQUENCIES IN SUBSONIC BOUNDARY LAYER

Moscow PRIKLADNAYA MATEMATIKA I MEKhanika in Russian Vol 48, No 2, Mar-Apr 84  
(manuscript received 8 Feb 83) pp 264-272

TERENT'YEV, Ye. D., Moscow

[Abstract] A quiescent rectangular plate with transition to a harmonically vibrating triangular end piece and with thermal insulation on all surfaces is immersed in a subsonic gas stream. The flow along the surface is describable by equations of a boundary layer with self-induced pressure. The motion of the vibrator at time  $t > 0$  is defined by the equation  $y_w = \sigma f(x, t) = \sigma f_1(x) \sin \omega_0 t$  (small parameter  $\sigma \ll 1$ , normalized frequency  $\omega_0 > 0$ ) with

$$\begin{array}{ll} f_1(x) = 0 & x \leq 0 \\ f_1(x) = 2x & 0 \leq x \leq b \\ f_1(x) = 2b(a-x)/(a-b) & b \leq x \leq a \\ f_1(x) = 0 & x \geq a \end{array}$$

The boundary layer is assumed to be quiescent ( $y_w = 0$ ) at time  $t < 0$ . The solution of the two-dimensional velocity and pressure problem for the lower region of the boundary layer with self-induced pressure, below the plane boundary layer and the subsonic outer stream, is sought in the form of a power series with respect to parameter  $\sigma$  and the smallness of this parameter permits retention of the first terms only and, consequently, reduction of the problem to a linear one. Vibration frequencies below the critical ( $\omega_0^* = 2.298$ , according to the theory of stability) were considered by the author in an earlier study (PRIKLADNAYA MATEMATIKA I MEKhanika Vol 45, No 6, 1981). Here vibration frequencies above the critical are considered. The problem is solved by Fourier transformation with respect to the longitudinal coordinate and Laplace transformation with respect to time, as Fourier transformation with respect to time is not technically feasible in this case. After elimination of some variables and change of other variables, a solution is obtained in terms of the Airy function for appropriate boundary conditions at infinity and at the surface. The pressure is calculated by inverse Fourier and Laplace transformations as the sum of two integrals, each analyzed and evaluated separately. Figures 4, references 9: 7 Russian, 2 Western.  
[237-2415]

## HYPERSONIC FLOW OF MIXTURE AROUND BLUNT BODY

Moscow VESTNIK MOSKOVSKOGO UNIVERSITETA, SERIYA 1: MATEMATIKA I  
MEKHANIKA in Russian No 3, May-Jun 84 (manuscript received 4 Jun 82) pp 54-62

SAGOMONYAN, A. Ya.

[Abstract] Hypersonic flow of a mixture around a blunt body is treated in the irrotational approximation, by extending the Lighthill method (M. Lighthill: Dynamics of Dissociable Gas) of solution for a homogeneous incompressible fluid behind the shock wave front to a compressible two-phase mixture. A symmetric body such as a sphere is considered in an originally velocity of sound. The mixture is a thermodynamically ideal gas containing solid particles or liquid drops in suspension, all assumed to be moving at the same hypersonic velocity. The corresponding two-dimensional equations of motion for this centrisymmetric problem are formulated in a polar system of coordinates with the origin at the center of the sphere and with the equation of state of the suspended phase given in the form  $p = f(\rho_2, p_2^0)$  ( $\rho_2^0$  - initial density of suspended substance,  $\rho_2$  - instantaneous density of suspended substances at any later time,  $p$  - corresponding pressure in mixture), disregarding any phases transformation of the suspended substance such as evaporation of liquid in the wave. These equations are solved for distributions of tangential and radial velocity as well as of gas pressure and particle concentration in and behind the wave, with appropriate boundary conditions stipulated at the surface. The pressure of the mixture at the stagnation point on the body, at the bow point of the wave, and at the gas stream splitting point between the other two is calculated with the aid of the Bernoulli integral. A method of solution is outlined for vortical hypersonic flow, thermodynamic relations being used for prior determination of the vorticity of each phase in the spherical bow shock wave. Figure 1, table 1, references 7 Russian.

[238-2415]

UDC: 539.3

NUMERICAL MODELING OF COMPLEX INTERACTION OF SHELL OF REVOLUTION AND ITS FILLER WITH ALLOWANCE FOR FRICTION

Moscow VESTNIK MOSKOVSKOGO UNIVERSITETA SERIYA 1: MATEMATIKA, MEKHANIKA in Russian No 2, Mar-Apr 84 (manuscript received 10 Dec 82) pp 85-89

MAKSIMOV, V. F. and KISELEV, A. B.

[Abstract] A numerical method is proposed for analyzing the interaction between a shell of revolution and its filler that can be used to solve the contact problem with allowance for deformation and disappearance of contact on the surface, as well as friction on the contact surface. It is found that as the coefficient of friction between the shell and the filler increases the regions of separation become smaller and the duration of separation of the filler from the shell becomes shorter. Allowing for friction reduces pulsations of the pressure of the filler on the shell. The introduction of friction between the shell and the filter has a significantly greater influence on the stress-strain state of the filler than of the shell. Figures 3, references 5 Russian.  
[217-6900]

UDC: 539.3

VARIABLE LOADING OF ELASTIC-PLASTIC SHELLS OF REVOLUTION

Moscow VESTNIK MOSKOVSKOGO UNIVERSITETA SERIYA 1: MATEMATIKA, MEKHANIKA in Russian No 2, Mar-Apr 84 (manuscript received 22 Jun 82) pp 67-71

TARAKANOV, S. I.

[Abstract] Axisymmetrical loaded shells of revolution are examined in which the median surface is formed by rotating a smooth curve about some axis. The Kirchhoff-Love hypotheses are used in deriving the basic formulas. The deformation and changes in curvature of the median surface of the shell occurring during loading are examined by the dynamic relaxation method. A closed cylindrical shell with constant thickness with variable loading is studied as an example. Figures 2, references 5 Russian.  
[217-6900]



UDC: 539.3:629.7.02

STABILITY OF CIRCULAR CYLINDRICAL SHELL WITH PIECEWISE CONSTANT THICKNESS  
SUBJECTED TO RADIAL PRESSURE

Kazan IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: AVIATSIONNAYA TEKHNIKA  
in Russian No 4, Oct-Dec 83 (manuscript received 14 Jul 82) pp 97-100

PROKOP'YEV, Ye. A. and RYABTSEV, V. A.

[Abstract] A method is proposed for solving problems of the stability of shells with stepwise varying (piecewise constant) thickness, which are easier to fabricate than shells with continuous change in thickness. The proposed method is used to solve stability problems of three shells subjected to constant radial pressure. The problem of the stability of an edge-articulated shell subjected to an external annular radial load is also solved. Figures 2, references 6 Russian.

[124-6900]

UDC: 629.7.025:539.374

STRENGTH ANALYSIS OF FAN-SHAPED WING CONSIDERING TEMPERATURE DEFORMATION  
AND CREEP DEFORMATIONS

Kazan IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: AVIATSIONNAYA TEKHNIKA  
in Russian No 4, Oct-Dec 83 (manuscript received 20 May 82) pp 85-88

KASHFRAZIYEV, Yu. A.

[Abstract] The supporting surface of a flight vehicle with a fan arrangement of the longerons is examined. The stress-strain state of such structures is determined with allowance for the influence of temperature deformations and creep deformations. Creep is found to cause substantial redistribution of stresses in the strength members, as well as the accumulation of residual deformations that can cause premature failure of supporting surfaces. Figures 2, references 5 Russian.

[214-6900]

UDC: 539.3:629.7.02

DEFORMATION OF CYLINDRICAL SHELL WITH CANTILEVERED ELASTIC PLATES ATTACHED

Kazan IZVESTIYA VYSSHIKH UCHEBNIKH ZAVEDENIY: AVIATSIONNAYA TEKHNIKA  
in Russian No 4, Oct-Dec 83 (manuscript received 3 Jan 83) pp 80-82

ANTUF'YEV, B. A.

[Abstract] An approximate solution is examined for the problem of the deformation of a thin elastic smooth cylindrical shell of finite length with two cantilevered elastic trapezoidal plates of variable thickness affixed. The problem is solved by dividing the shell into two identical panels and examining one of them. A numerical example of a uniformly stressed shell is presented. Figures 3, references 2 Russian.  
[214-6900]

UDC: 539.4:629.7.02

ANALYSIS OF THIN-WALLED AIRFRAME MEMBERS IN GEOMETRICALLY NONLINEAR STATEMENT

Kazan IZVESTIYA VYSSHIKH UCHEBNIKH ZAVEDENIY: AVIATSIONNAYA TEKHNIKA  
in Russian No 4, Oct-Dec 83 (manuscript received 10 Feb 83) pp 52-56

PAVLOV, V. A. and SAFONOV, A. S.

[Abstract] A geometrically nonlinear analytical theory is developed that allows the influence of axial shifting on the stress-strain state of a structure to be assessed. A theory proposed by Yu. G. Odínokov is extended to include geometrically nonlinear problems. Nonlinear integral differential matrix equations are derived for determining the stress-strain state of a thin-walled structure with allowance for geometric nonlinearity. Figures 2, references 5 Russian.  
[214-6900]

UDC: 629.7.02:539.4

ANALYSIS OF COMPOSITE GLUED SHELLS OF REVOLUTION

Kazan IZVESTIYA VYSSHIKH UCHEBNIKH ZAVEDENIY: AVIATSIONNAYA TEKHNIKA  
in Russian No 4, Oct-Dec 83 (manuscript received 1 Jun 81) pp 47-52

MARTYSHEV, V. P.

[Abstract] The stress-strain state in elements of a composite shell is represented as the sum of the momentless state and the boundary effects in the vicinities of the ends of the composite shell and the boundaries of the

glued layer. Allowance is made for the nonlinear characteristics of the glue layer by using the method of variable elasticity parameters. Equations are derived for each state for determining the stresses in the glue layer and the force factors and deformations in the shells. Figures 2, references 3 Russian.  
[214-6900]

UDC: 621.981.2.04

THEORETICAL AND EXPERIMENTAL INVESTIGATION OF FLEXING-ROLLING PROCESS OF CONICAL SHEET FLIGHT VEHICLE PARTS

Kazan IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: AVIATIONNAYA TEKHNIKA  
in Russian No 4, Oct-Dec 83 (manuscript received 15 Jun 83) pp 41-47

LYSOV, M. I. and SOSOV, N. V.

[Abstract] A model of spring action is developed to account for mutual effects of cross sections. The spring action of conical parts is analyzed assuming  $N_{z\bar{z}}$  to be zero and assuming minimum potential energy. The method can also be used for parts that are not conical during the active stage of loading. If a part becomes conical during the active stage, both spring action components can be found simultaneously on the basis of the principle of minimum total potential energy. Figures 3, references 2 Russian.  
[214-6900]

UDC: 629.7.023.4

ALGORITHM FOR OBTAINING RIGIDITY MATRIX FOR FINITE ELEMENT OF ANISOTROPIC SHELL

Kazan IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: AVIATIONNAYA TEKHNIKA  
in Russian No 4, Oct-Dec 83 (manuscript received 28 Jan 83) pp 14-18

BAKULIN, V. N., KRIVTSOV, V. S. and RASSOKHA, A. A.

[Abstract] A finite element of a laminated anisotropic shell with double curvature with allowance for deformations of transfer shifting is proposed. The proposed finite element can be used in numerical solutions of problems in the theory of laminated anisotropic shells when analytical solutions are difficult. Figures 3, references 5: 3 Russian, 2 Western.  
[214-6900]

## STABILITY OF HOLLOW SHAFTS UNDER TORSION

Kiev PROBLEMY PROCHNOSTI in Russian No 1, Jan 84  
(manuscript received 28 Jan 83) pp 58-62

ALEKSEYEV, V. I., Kuybyshev

[Abstract] The static load capacity of smooth hollow shafts under torsion is evaluated theoretically, considering that it depends on the resistance to plastic deformation and can be much lower than under plain shear. The critical stresses in this problem are calculated according to the theory of thin cylindrical shells, on the basis of the physical state of stress and strain at the elastic limit. Certain coefficients and exponents in the resulting relations are empirical, their values having been determined experimentally for two grades of steel: EI961 silicon steel and 38Kh8MYuASh chromium steel. As the ratio  $\alpha = d/D$  of inside diameter to outside diameter increases from 0.7 to 0.97, the ratio  $K_0 = M_t/M_s$  of marginal twisting moment to ultimate shearing moment increases from 0.58 to 0.7 and the load capacity decreases correspondingly. Calculations by this method yield somewhat higher critical loads than indicated by measurements, but the difference does not exceed 3-4%. The results are applicable to tubular torsion springs as well as to hollow rotating shafts, smooth or slotted, under axial loads in addition to centrifugal forces. Figures 4, tables 2, references 6 Russian. [199-2415]

UDC 539.3

## ST. VENANT CONDITIONS IN THEORY OF PIEZOELASTIC SHELLS

Moscow PRIKLADNAYA MATEMATIKA I MEKHANIKA in Russian Vol 48, No 2,  
Mar-Apr 84 (manuscript received 15 Jun 83) pp 302-306

ROGACHEVA, N. N., Moscow

[Abstract] The equations of piezoceramic shells and of corresponding boundary layers are formulated in a triorthogonal system of coordinates, two curvilinear axes constituting respective lines of curvature of the median surface and one rectilinear axis normal to both. The direction of prepolarization is taken into account, assuming this direction to be along one of the curvilinear axes. After the coordinates have been stretched in the direction of maximum change in variables (widthwise), according to the asymptotic method, calculation of the boundary layer reduces to solution of a plane problem and an antiplane one for a piezoceramic half-strip with homogeneous boundary conditions at the faces. Arbitrary electrical and mechanical loads are assumed to be acting at the free edge of such a half-strip. Stipulation of Saint Venat boundary conditions at electroded and non-electroded faces in each problem requires that an electrical condition be

added to the conventional mechanical ones at nonelectrodized faces. This extends the Saint Venant principle to elastic shells under both electrical and mechanical loads at the edge: while in a plain elastic shell a not self-balanced mechanical load produces a stressed-strained state that decays at the edge, in a piezoceramic shell an electrical load at the edge, whether self-balanced or not, produces an electroelastic state that decays exponentially with increasing distance from the edge. Only such loads, electrical and mechanical, need to be considered in calculations of the internal stressed-strained state. References 4 Russian.  
[237-2415]

UDC 531.011+62-50

CONTROLLABLE ROTATION OF SYSTEM OF TWO SOLID BODIES WITH ELASTIC ELEMENTS

Moscow PRIKLADNAYA MATEMATIKA I MEKhanika in Russian Vol 48, No 2,  
Mar-Apr 84 (manuscript received 30 Jun 83) pp 238-246

BERBYUK, V. Ye., L'vov

[Abstract] A mechanical system is considered that consists of two solid bodies connected through an elastic bar of variable cross section. This bar is at one end coupled to the carrier body by a weightless spring constituting a hinge joint and simulating an elastic fastener, at the other end it is rigidly clamped to the rider body of dimensions much smaller than the length of the bar. The system can rotate in some plane and such rotation is evaluated here from the standpoint of controllability. The analysis is based on the linear theory of inextensible slender straight beams, with the equations of motion formulated according to the Hamilton-Ostrogradskiy variational principle. Longitudinal oscillations are disregarded, both kinetic energy and potential energy are expressed with second-order precision, the radius-vector and the relative velocity of any point along the bar as well as the angular velocity of the system are expressed in the linear approximation with respect to additional angular displacement owing to compliance of the hinge joint. Boundary and initial conditions are then stipulated for the resulting system of integrodifferential equations, for subsequent controllability analysis. This analysis in the quasi-static approximation, with the case of zero initial conditions as an important specific example, is followed by an analysis for a bar with high flexural stiffness and infinitely high flexural stiffness (bar without carrier and hinge joint) as limiting case. Figure 1, references 13: 11 Russian, 2 Western.  
[237-2415]

## MOTION OF HEAVY SYMMETRIC BODY WITH FLEXIBLE BARS ABOUT STATIONARY POINT

Moscow PRIKLADNAYA MATEMATIKA I MEKhanika in Russian Vol 48, No 2, Mar-Apr 84  
(manuscript received 1 Feb 83) pp 233-237

VIL'KE, V. G., Moscow

[Abstract] Motion of a symmetric solid body about its center of mass is analyzed, this body having two pairs of collinear identical bars attached to it in quadrature along the principal axes in the equatorial plane of the ellipsoid of inertia. The deflection of the bars is calculated from the kinetic energy and the momentum of the system, using the Routh functional and applying the theory of flexure for viscoelastic slender straight beams. After a change from canonical to Andoyer variables, the corresponding equations are solved for appropriate kinematic and dynamic boundary conditions, with dissipation forces represented as those of linear viscous internal friction. The solutions for undeformable stiff bars describe regular precession of an Euler body. The solutions for slightly flexible bars with small strain describe damped forced vibrations of such bars. A transient and stability analysis of the angular momentum vector by the method of averaging, under constraints which validity of this method imposes on the moments of inertia, indicates that motion of the system evolves approaching steady rotation about the vertical axis. References 6 Russian.  
[237-2415]

TESTING AND MATERIALS

UDC 669.35:621.822

TESTING THE ANTIFRICTION PROPERTIES OF ALLOYS FOR HEAVILY LOADED BEARINGS

Moscow VESTNIK MASHINOSTROYENIYA in Russian No 3, Mar 84 pp 21-23

YAMSHANOV, P. I., candidate of technical sciences and LEBEDEVA, V. V.,  
engineer

[Abstract] The antifriction properties of bearing alloys were studied using samples 200 mm in diameter, 250 mm long, at a sliding rate of 4.8 m/s and a sample load of from 180 to 1,000 N, both with and without lubrication. The tests of the nonferrous alloy samples (high strength brass, tin-bronze, tin-lead and tin-phosphorous bronzes) were performed on a DIP200 lathe at 500 r.p.m. by pressing a sample of 5KhNM steel with a surface roughness of  $R_a = 0.40$  micrometers against the tested surface. The sample surface was 20 x 20 mm with a hardness of HRC 18-52. The wear and strength of 7 different alloys were evaluated for these severe conditions. The most suitable for the fabrication of heavily loaded bearings are tin-lead and tin-phosphorous bronzes. Bronzes and brass without tin do not meet the high load antifriction and antiseizing criteria. The method used here can also be employed for the development of new alloys for heavily loaded bearings as well as for studying the mechanism of friction and wear for real loads and slip rates. Figures 3, table 1.  
[195-8225]

SOME FACTORS INFLUENCING FABRICATION OF RIGID FOAM-FILM SOLAR CONCENTRATORS

Tashkent GELIOTEKHNICA in Russian No 2, Feb 84  
(manuscript received 4 Feb 83) pp 37-40

URAYDULLAYEV, A. K., KAGAN, M. B., ATAULLAYEV, O. Kh., SOBIROV, O. Yu. and RABBIMOV, R. T., Navoi Affiliate, Tashkent Polytechnical Institute imeni A. R. Beruni

[Abstract] The strength of the bond between the reflecting film form (substrate) of a foam-film concentrator and the adhesive coating (epoxy resin or polyurethane foam) is investigated. The strength of the bond between the substrate and coating molecules depends upon mechanical bonding, chemical interaction and electrostatic forces, with the structure of the polymer coating being of major importance. Experiments are conducted to study the separation of the reflecting surface from the rigid polymer coating. The experimental findings are analyzed, and a concentrator fabrication method is proposed that permits the devices to be employed as optical mirrors in high temperature systems for conducting physical-chemical investigations of materials and for converting radiant energy to electricity. Figures 5, references 6: 3 Russian, 3 Western.  
[232-6900]

OBTAINING FILMS OF THREE-COMPONENT  $Zn_xCd_{1-x}S$  SYSTEM BY CHEMICAL PRECIPITATION OF ORGANOELEMENTAL COMPOUNDS FROM VAPOR PHASE IN HYDROGEN STREAM

Tashkent GELIOTEKHNICA in Russian No 2, Feb 84 (manuscript received 24 Feb 84) pp 63-65

AZIMOV, S. A., RAZYKOV, T. M. and KADYROV, B. Kh., Physical-Technical Institute imeni S. V. Starodubtsev

[Abstract] The possibility of creating efficient, economical thin-film photovoltaic cells based on solid solutions of  $A^2B^6$  semiconductor compounds by chemical precipitation of organoelemental compounds from vapor phase in a stream of hydrogen is discussed. It is shown possible to obtain films of solid solutions of  $A^2B^6$  by this method, using films of the ternary compound  $Zn_xCd_{1-x}S$  as an example. Initial findings indicate the method to be very promising. References 15: 8 Russian, 7 Western.  
[232-6900]



UDC: 621.362:621.383.5

#### PHOTOVOLTAIC CELL TEMPERATURE SENSOR

Tashkent GELIOTEKHNICA in Russian No 1, Jan 84  
(manuscript received 11 May 82) pp 12-16

LETIN, V. A. and KHOLEVA, M. N., All Union Order of Labor Red Banner  
Scientific Research Institute for Current Sources

[Abstract] A temperature sensor is developed that measures the temperature of photovoltaic cells accurately and reliably, and provides longer service life than metal thermoresistive or doped semiconductor-based devices. The device developed consists of a silicon single crystal plate with a doping concentration of  $10^{16}$ - $10^{17}$  cm<sup>-3</sup>. Experimental sensors provided a maximum temperature measurement error of 4°C, with a maximum resistance measurement error after 50 thermal cycles not exceeding 2%. Figures 3, references 8: 6 Russian, 2 Western.  
[218-6900]

UDC: 662.997:537.22(088.8)

#### INVESTIGATION OF RADIATING CAPACITY OF HELIONICS MATERIALS AND SELECTIVE COATINGS AT WORKING TEMPERATURES

Tashkent GELIOTEKHNICA in Russian No 1, Jan 84 (manuscript received 2 Jun 82)  
pp 17-19

ALAYEV, E. A. and KOLUTIN, M. M., All Union Order of the Labor Red Banner  
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[Abstract] Devices incorporating a thermal electric sensor for measuring the blackness of the surfaces of solar installations before and after selective optical coatings are applied are tested at the working temperatures of the solar installations. The device employs the radiation method to find the coefficient  $\epsilon$ , using an ideal black body as the standard of comparison. The radiating capacity of copper-, aluminum- and nickel-based helionics materials are found, and the radiating capacity of selectively coated solar installation surfaces is analyzed and tabulated. References 9: 8 Russian, 1 Western.  
[218-6900]

UDC: 620.181.4:536.521.3.536.33

METHODS FOR THERMAL ANALYSIS OF HIGH TEMPERATURE CERAMICS ON RADIANT HEATING INSTALLATIONS

Tashkent GELIOTEKHNIKA in Russian No 1, Jan 84 (manuscript received 8 Feb 83)  
pp 20-23

AZIMOV, S. A., KAN, V. V., RUMI, R. F., SIGALOV, L. M. and KHATRAYEVA, M.,  
Physicotechnical Institute imeni S. V. Starodubtsev, UzSSR Academy of Sciences

[Abstract] The capabilities of two methods for determining the true temperature of high temperature ceramics are compared: formation of a "black body" model from the investigated material, and photometry of the open surface of the specimen. The latter method, which is found to be superior, is modified to find the phase transition temperatures from the cooling curves. This modification makes it possible to determine the crystallization and phase transition temperatures in the solid state. Figures 2, references 5:  
3 Russian, 2 Western.  
[218-6900]

UDC 549.641:546.34

MECHANICAL TREATMENT OF GLASS TUBES

Leningrad OPTIKO-MEKHANICHESKAYA PROMYSHLENNOST' in Russian No 2, Feb 84  
(manuscript received 6 Jun 83) pp 44-45

AZAROV, A. S., VASIN, L. N., KALUGIN, F. I. and FOLOMEYEV, A. V.

[Abstract] A high-precision fabrication technology is proposed for optical glass tubes, specifically tubes of  $350 \pm 50$  mm length with  $23.8 \pm 0.05$  mm diameter and  $3.6 \pm 0.02$  mm wall thickness. Such tubes are produced from monolithic bars of given length and  $34 \times 34$  mm square cross section. The fabrication process consists of several stages. First the faces at both ends of the bar are ground, whereupon a hole  $23.2 \pm 0.2$  mm in diameter is bored on a "Cincinnati" circular grinding machine with a 160/125 diamond drill rotating at 3000 rpm and fed 20-30 mm/min. A 10% aqueous solution of Emulsol is used as lubricant-coolant fluid, this operation producing a hole with surface roughness  $R_z \leq 20$   $\mu$ m and noncylindricity  $\Delta c \leq 0.02$  mm. In the next stage the outside surface of the bar is turned on a lathe, after preliminary milling with a 200/160 diamond cutter of grade ASR material and ABP shape rotating at 3000 rpm. Here a lubricant-coolant fluid is used, continuously, this operation producing a round outside surface  $32.1 \pm 0.05$  mm in diameter with roughness  $R_z \leq 20$   $\mu$ m and noncircularity  $\Delta c \leq 0.03$  mm. The inevitable variation of wall thickness is reduced to permissible level by finish turning on a ZE-12 circular grinding machine in stationary pivots, with an 80/63 diamond wheel of APP shape rotating at 1930 rpm while the tube is

rotated at 300-400 rpm. Here the longitudinal feed is 0.6-0.8 mm/min and the two-pass transverse feed is 0.3/0.005 mm/min, this operation producing a round outside surface  $31.6 \pm 0.05$  mm in diameter with roughness  $R_z \leq 2.5 \mu\text{m}$  and a wall with thickness variation  $\Delta t \leq 0.03$  mm. There follow polishing with microabrasive powders and then lapping with cloth, each of these operations at appropriate speed of rotation and frequency of oscillation being performed first on the faces and chamfers, then on the inside surface, then on the outside surface. This technological process is still imperfect, mainly because it requires too much labor, and further improvements are sought.

[235-2415]

UDC 666.1.053

#### FEASIBILITY OF VIBRATORY FINE GRINDING OF GLASS ENTRANCE WINDOWS

Leningrad OPTIKO-MEKHANICHESKAYA PROMYSHLENNOST' in Russian No 2, Feb 84  
(manuscript received 29 Dec 82) pp 42-43

MASLOV, S. P., KRUIHKOV, A. V., KABANOVA, I. Yu., YEVSTISHENKOV, V. S.,  
MAKHLINA, G. A. [deceased] and MEDVEDEVA, I. M.

[Abstract] An experimental study was made to establish the feasibility of vibratory fine grinding of glass, specifically entrance windows of photoelectronic devices, this process being already used on metal and plastic parts. The experimental equipment consisted of a platform on spring mountings with an unbalanced shaft underneath and several U-form toroidal vessels standing on top. Vibration of the platform and vessels was produced by rotation of the shaft, the latter driven by an electric motor through a belt transmission. Vibration of a vessel containing granular abrasive material, with attendant circular and oscillatory motion of abrasive particles and of the glass part immersed in them, subject the latter to micro-impacts and microcuts uniformly and simultaneously over the entire treatable surface. The process was tested with SiC abrasive on three optical glasses (K8, S50-4, S52-2), disks of various sizes having been rough ground with a 160/125 diamond tool. The surface finish was measured with a "Kalibr 252" profilograph-profilometer and the surface examined under an MII-4 optical microscope, then after polish and chemical cleaning under an MBS-2 optical microscope. The abrasion factor, relative loss of mass, and the surface roughness ( $R_a$ ,  $R_z$ ,  $H_{\text{max}}$ ,  $H_{\text{min}}$ ) were determined as functions of the vibration amplitude and frequency as well as of the carbide grain size (M10-M40). The results were found to be consistently as good as or better than those obtained by classical fine grinding. The optimum vibration for fine grinding of glass entrance windows of photoelectronic devices is vibration with 0.5-1.0 mm amplitude at 40-46 Hz frequency. Figure 1, tables 3, references 3 Russian.

[235-2415]

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